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MEMOIRS

OF THE

GEOLOGICAL SURVEY OF GREAT BRITAIN,

AND OF THE

MUSEUM OF PRACTICAL GEOLOGY

IN

LONDON.

VOLUME THE SECOND.

PART I.

MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

GREAT BRITAIN,

AND OF THE

MUSEUM OF PRACTICAL GEOLOGY IN LONDON.

VOL II.—PART I.

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CONTENTS.

Vol. II., Part 1.

Page

The Malvern Hills compared with the Palæozoic Districts of Abberley, &c. By John Phillips, F.R.S. 1

Palæontological Appendix to Professor John Phillips' Memoir on the Malvern Hills compared with the Palæozoic Districts of Abberley, &c. By John Phillips, F.R.S., &c., and John William Salter, A.L.S., F.G.S. 331

LIST OF PLATES.

Vol. II., Part 1.

1. Geological Map of the Silurian Districts of Abberley, Malvern, Woolhope, May Hill, and Tortworth.
2. Geological Map of Ankerdine, Ridge Hill, and Abberley Hill.
3. Plan and Section of Pyrton Passage, Gloucestershire.

(*Plates* 4 *to* 30 *inclusive, Organic Remains.*)

4. Trachyderma coriacea, Tr. squamosa.
5. Phacops Stokesii, Ph. Downingiæ, Dalmannia affinis, Illænus Rosenbergii.
6. Proetus latifrons, and other species.
7. Sphærexochus clavifrons, *Dalm.* (juvenis, *of the plate*) Cheirurus speciosus.
8. Illænus Bowmanni, Liches laxatus, L. verrucosus, Cybele sexcostata, Agnostus trinodus, Ag. β convexus, Beyrichia tuberculata, B. complicata, B. gibba.
9. Trinucleus ornatus, Acidaspis bispinosus, A. Brightii.
10. Ampyx parvulus.
11. Calymene brevicapitata.
12. Calymene tuberculosa.
13. Orthoceras Marloense, O. textile.
14. Theca anceps, Loxonema (Terebra) sinuosa, Murchisonia polyglypha, Pleurotomaria quadristriata, Pl. fissicarina, Euomphalus qualteriatus, E. alatus, E. prænuntius Bellerophon obtectus.
15. Pleurotomaria balteata.
16. Pleurorhynchus æquicostatus.
17. Orthonota cingulata, O. extrasulcata.
18. Orthonota triangulata.
19. Orthonota rigida, O. inornata.
20. Mytilus quadratus, M. perovalis, M. gradatus, M.? unguiculatus, M. (Inoceramus) mytilimeris, M. (Inoceramus) Chemungensis, M. exasperatus, M. platyphyllus.
21. Actinodonta cuneata, Arca primitiva.
22. Nucula coarctata, N. deltoidea, N. lingualis, N. rhomboidea.
23. Avicula ampliata, A. (Pterinea?) planulata, A. Triton.
24. Lingula crumena.
25. Lingula granulata.
26. Lingula parallela, Orbicula Forbesii, Leptæna lepisma, *var.* minor.
27. Strophomena applanata, Orthis inflata, O. testudinaria.
28. Hypothyris semisulcata, Hy. borealis.
29. Palechinus Phillipsiæ.
30. Serpulites curtus, Favosites? ramulosa, Actinophyllum plicatum, Onchus decorus.

MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

GREAT BRITAIN, &c.

The Malvern Hills, compared with the Palæozoic Districts of Abberley, Woolhope, May Hill, Tortworth, and Usk. By JOHN PHILLIPS, F.R.S., &c.

PRELIMINARY NOTICE.

THE Geological Survey of the Malvern Hills, of which the condensed results appear in the following pages, was commenced in April, 1842. The facts which it disclosed rendered it desirable, and it was found convenient, for the same observer to undertake the examination of the districts of Woolhope and Abberley, and of the country bordering upon and connecting these remarkable ranges of hills. A great proportion of this work was performed in the course of the year; but the author has had several opportunities of reviewing (in 1843, 1844, and 1845) some of the complicated phenomena which he had recorded, and of confirming, by careful research, the reasonings which had been suggested by the first survey.

The facts and conclusions established in the districts of Malvern, Abberley, and Woolhope, are the basis from which, in the following pages, comparisons are extended to May Hill, Tortworth, and Usk, and in a general sense to the whole line of Silurian deposits in South Wales, from Llandovery to St. Bride's Bay.

By direction of Sir H. De la Beche, all those districts have been minutely inspected by the author, and all the fossils which they have yielded have passed through his hands for examination; the object of this arrangement being to unite in one mind a personal knowledge of the Lower Palæozoic fossils, and of the local, physical, and geological conditions under which they were discovered. More than this indeed was accomplished; for the activity of the Director of the Survey allowed

him to examine, and discuss on the spot, and often at the time of its discovery, almost every important fact; and a spirit of philosophical inquiry was thus excited and encouraged, which has pervaded every member of the Survey.

The collections just referred to contain several new species of organic remains, but it was not on this account, nor on account of the beauty of some particular specimens, that so much care was taken in forming them. They include examples from *all the strata*, and from most of the localities of importance in all the districts which have been named; they include *all the species* which were discoverable by the collector at the time when he was at work; and may, therefore, be trusted as good data for numerical estimates and comparative tables of the distribution of life in the ancient sea, during successive Palæozoic periods.

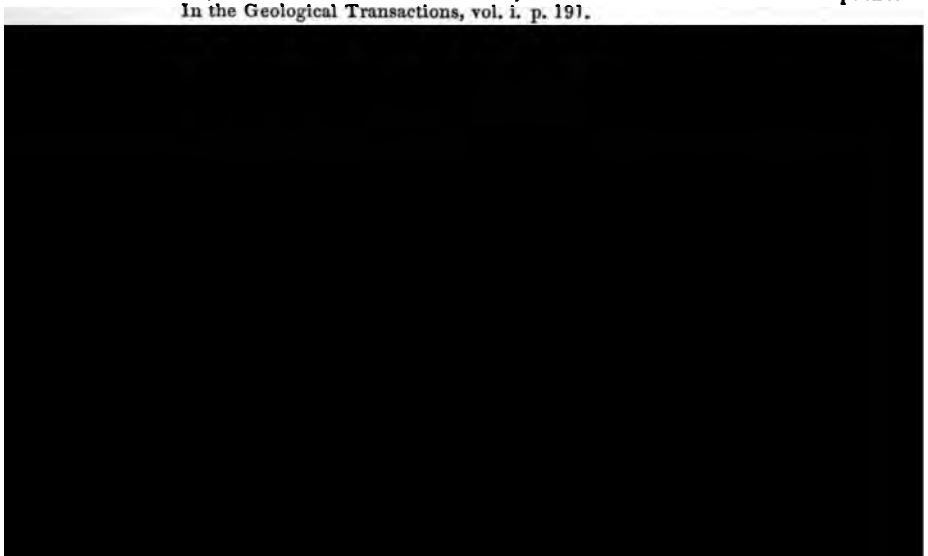
It is only necessary to add, that the map and sections of May Hill are taken from the survey of that district executed under the immediate superintendence of Sir H. De la Beche; and that, excepting a few lines drawn by the author, the vicinity of Tortworth is extracted from the field-work of Mr. Williams, Mr. Ramsay, and Mr. Sanders.

The principal notices already published of the Malvern Hills, and the other districts with which they are in the following pages compared, may be found by the subjoined references.

1811. Horner, Leonard, F.G.S. On the Mineralogy of the Malvern Hills. In the Geological Transactions, First Series, vol. i. p. 281.

In this excellent Memoir the syenitic range of hills is described, the varying composition and structure of the rocks are indicated, and the local reversal of the strata on the west side of the Malvern chain distinctly recorded.

1811. Aikin, Arthur, F.G.S. On the Wrekin, and the Great Coal Field of Shropshire. In the Geological Transactions, vol. i. p. 191.



1821. Henslow, Rev. Professor, F.G.S. Geological Description of Anglesea. In the Cambridge Philosophical Transactions, vol. i. p. 359.

The dyke of Plas Newydd, which produces remarkable metamorphic effects on the adjoining strata, is fully described in this valuable paper, which is very well illustrated by maps and sections.

1822. Conybeare, Rev. John, F.G.S. On the Geology of the Malvern Hills. In the Annals of Philosophy, New Series, vol. iv. p. 337.

The author adds some further particulars of the occurrence of a brecciform trap in the Malvern Hills, which had been already noticed by Mr. Horner and Mr. W. Phillips.

1825. Yates, James, F.G.S. On the Structure of the Border Country of Wales. In the Geological Transactions, Second Series, vol. ii. p. 237.

Several interesting sections along the line of junction of the Grauwacke (now called Silurian) rocks of Wales and the limestone of the English border, from Llangollen to Ludlow, are described. The rocks of Church Stretton, the Lawley, and Caer Caradoc are noticed; and the detached districts of Dudley, Bromsgrove, Nuneaton, and Charnwood Forest are investigated, as containing rocks more or less similar to those already described.

1832. Wright, J. R. On the Secondary Formations in the Neighbourhood of Ludlow. In the Proceedings of the Geological Society, vol. i. p. 387.

1836. Addison, William, F.L.S. On the Medical Topography of Malvern, and of the District at the base of the Malvern Hills. In Transactions of the Provincial Medical and Surgical Association, vol. iv. p. 87.

It contains a very good series of meteorological observations, with analytical tables of results, lists of rare plants, and other useful information.

1837. Murchison, Sir R. I., G.C.S., F.R.S. G.S. The Silurian System. 4to. 2 vols.

In this splendid work all the districts which are noticed in the following Memoir, from the Severn to St. Bride's Bay, are described and admirably illustrated by maps, sections, and figures of organic remains. The general views and classifications delivered in these volumes are so well supported by subsequent observations on a large scale, and often repeated, as to have obtained the first place among the established results of Palæozoic Geology. It is chiefly in the extent and distribution of trap rocks about the south-western end of the Malverns and along the Abberley range, that the map appended to this Memoir differs sensibly from that given in the 'Silurian System.'

Sir R. I. Murchison's researches in Siluria commenced in the summer of 1831. The first notice of his progress was made to the meeting of the British Association at York in the same year. His first paper on

the subject was read to the Geological Society of London in March, 1833.

1837. Murchison, Sir R. I., G.C.S., V.P.G.S., and Strickland, H.E., F.G.S. On the Upper Formations of the New Red Sandstone System in Gloucestershire, Worcestershire, and Warwickshire. In the Transactions of the Geological Society, New Series, vol. v. p. 331.

This paper is illustrated by a map, sections, and plates of organic remains in the 'Keuper' sandstone.

1838. Sedgwick, Rev. Professor, F.R.S. G.S. Synopsis of the English Series of Stratified Rocks. In the Proceedings of the Geological Society, vol. ii. p. 675.

This communication includes the first general view which the Professor made public, of the progress of his researches in Wales, begun in 1832 and 1834, contemporaneously with the labours of Sir R. I. Murchison.

1843. Sedgwick, Rev. Professor. Outlines of the Geological Structure of North Wales. In Proceedings of the Geological Society, vol. iv. p. 212.

The strata of North Wales are here grouped in three divisions, clearly defined, and placed in their position on the scale of organic life which measures the Silurian periods.

1838. Trimmer, Joshua, F.G.S. On the Diluvial or Northern Drift of the Eastern and Western Sides of the Cambrian Chain. In the Journal of the Geological Society of Dublin, vol. i. p. 286 and p. 335.

1840. Bowman, John E., F.L.S. G.S. On the great Development of the Upper Silurian Formation in the Vale of Llangollen, North Wales; and on a Plateau of Igneous Rocks on the east flank of the Berwyn Range.

1841. Bowman, John E. On the Upper Silurian Rocks of Denbighshire.

The author in this paper estimates the total thickness of the Upper Silurians of Denbighshire at 4800 feet. The uppermost beds are green

INTRODUCTORY VIEW.

There is a line strongly traced by nature between the estuary of the Dee and that of the Severn, which coincides with the physical and almost with the old political line of separation between Wales and England. This line, passing at the foot of the Flintshire and Denbighshire hills, winding by Shrewsbury, Bridgenorth, and Bewdley, and touching the Abberley, Malvern, and May hills, strikes the Severn at Pyrton Passage.

On the west of this line the whole region is mountainous, and principally composed of the older classes of marine strata, mixed with various coeval rocks the effects of local igneous action; on the east of it extend immense breadths of less ancient deposits, pierced at a few detached points by the rocks which rise higher and spread more widely to the westward. The country on the west belongs generally to the Palæozoic, that on the east to the Mesozoic ages of geology.

For a great part of its course this line is coincident with great movements of the ground which followed the period of the carboniferous strata, and left a long, winding, and broken cliff, against which the sea acted with violence, and heaped conglomerates, sandstones, and marls, all rich in red oxide of iron, but almost devoid of traces of organic life. The accompanying geological maps and sections will shew the general character and distribution of the rocks on both sides of this very ancient line of coast, in the country embraced by this Memoir.

For the sake of a clear and concise view, the descriptions which follow commence with the district where the strata have been laid open by nature to the greatest depths and under the most varied and interesting relations; viz., the Malvern Hills and the region immediately and naturally related to and, in a geological sense, dependent upon them. From this point as a basis, it is proposed to extend comparisons, both geological and palæontological, to the cognate districts of Abberley, Woolhope, May Hill, Tortworth, and Usk, and in a more general sense to the whole of the large connected areas of Palæozoic rocks in Wales, which have been sufficiently examined in the course of the geological survey. The districts named have to each other one general relation; they are all parts of the ancient Silurian sea bed, which were covered up several thousand feet deep by a deposit of old red sandstone, and, in part, at least, by some additional thousands of feet of mountain limestone and coal strata; and from this depth of two or three miles below the horizon they were all elevated, so as to be above the sea previous to the deposit of the new red sandstone.

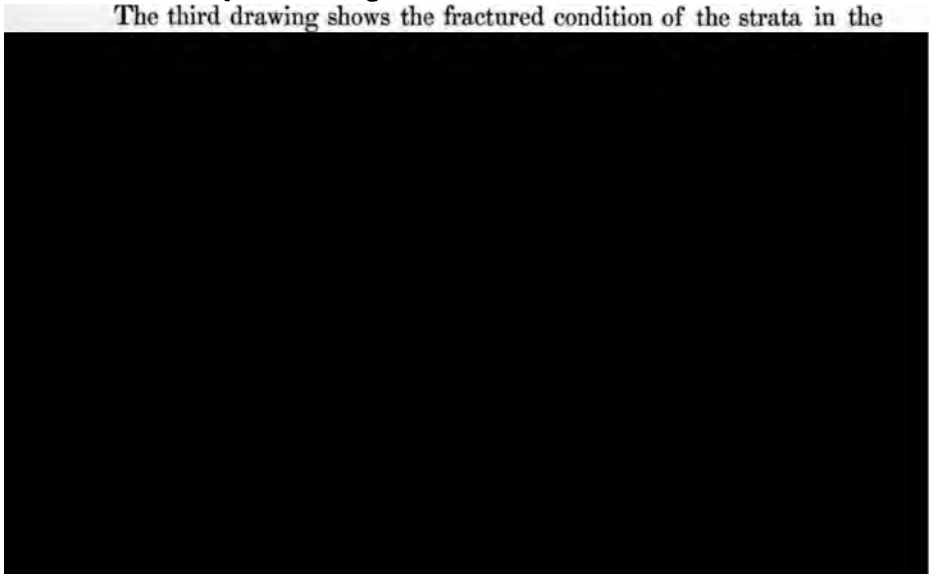
It is probable that this elevation acted at once (or rather was continually acting during one period of undetermined duration) on all these points, and also on the whole area of Silurian strata in South Wales, North Wales, and some other separated districts.

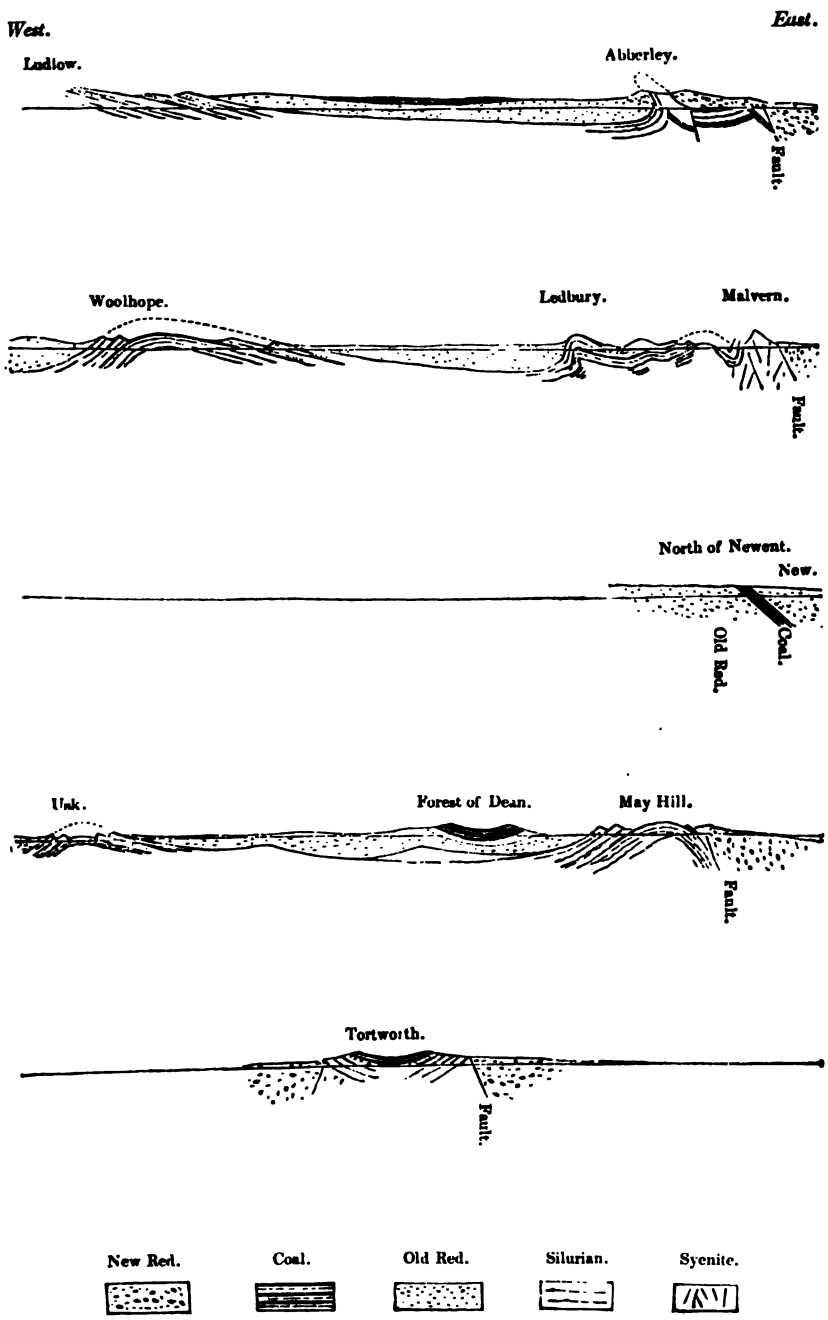
The accompanying series of sections, arranged so as to correspond with the map, will show the general character of the positions acquired by the rocks in each of the districts, and the connexion to the one great eastern line of disturbance, which has been already noticed, of several synclinals and anticlinals on the west, which form the districts of Usk, Woolhope, and Ludlow. The drawings are too small for the representation of details, but may be depended on for general truth of meaning.

It will be perceived that in the northern or Abberley district the Silurian strata, broken off on the east against the red sandstones, are folded, and fractured, and reversed towards the west; there becoming covered up by old red sandstone and *the coal formation*, in a deep and broad synclinal, from which they emerge and rise westward in the vicinity of Ludlow.

The second drawing represents the characteristic structure of the Malvern district and its connexion westward with the forest of Woolhope. On the eastern side of the Malvern district rocks of igneous origin appear in a long ridge, broken off against the new red sandstone. Bent by the same force which broke and displaced the Abberley rocks, the Silurian strata on the west are folded in several great ridges and hollows, parallel to the axis of igneous rocks, and finally are caused to sink almost perpendicularly downward, under a great broad synclinal hollow of old red sandstone, *without coal,* from which, at a moderate angle of inclination, the strata reappear and rise to the broad anticlinal arch of Woolhope, which terminates on the west by a very steep inclination to a synclinal trough.

The third drawing shows the fractured condition of the strata in the




West.
East.
Ludlow.
Abberley.
Fault.
Woolhope.
Ledbury.
Malvern.
Fault.
North of Newent.
New.
Old Red.
Coal.
Usk.
Forest of Dean.
May Hill.
Fault.
Tortworth.
Fault.
New Red.
Coal.
Old Red.
Silurian.
Syenite.

the Palæozoic rocks against the red marls is matched by a similar interruption to their continuity on the west. The interior of this district is a synclinal basis of Silurian, old red, mountain limestone, and coal strata.

Finally, it may be remarked as a fact, that the movements of the earth's crust, to which these disturbed positions are due, extended under a great part of South Wales, and even across the Channel through the south of Ireland. In consequence of this extensive elevation, and the exposure at points so distant as Malvern and Marloes, of Silurian strata which were formed in the same oceanic basin, we are able to survey the distribution of organic life in several successive Palæozoic æras, with as much certainty and completeness as can now be attained by the most persevering dredging operation for one surface and one epoch of modern life. The distribution of Palæozoic life will therefore form a special object of inferences founded on data collected in the course of the Geological Survey. The publication of these data, by carefully engraved figures of fossils, diagrams of stratification, and maps of districts, is in progress.

The geology of the Malvern Hills, assumed as the general term of comparison, being almost unconnected with questions touching the carboniferous deposits, any notices of these strata will be restricted to matters which necessarily attract attention or contribute to illustrate the main subject. For the same reasons the remarks on the oolitic formations will be merely incidental, the great variety of curious information now collected concerning them requiring separate and ample discussion.

From the South.

Silurian Rocks near Ledbury, in light.

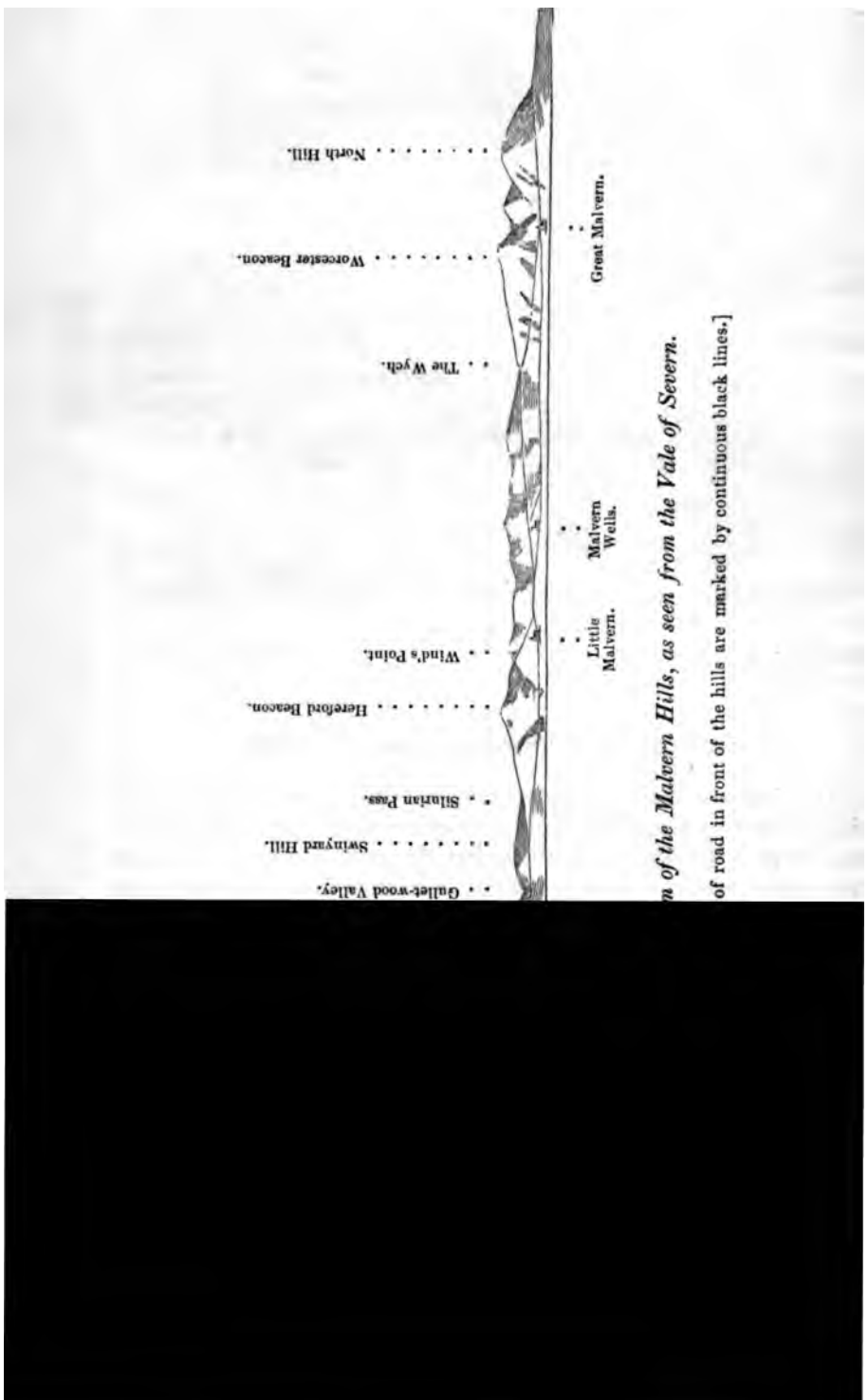
Syenitic Malvern Hills, in shade.

PHYSICAL GEOGRAPHY OF THE MALVERN HILLS.

The Malvern Hills constitute a narrow ridge of country, elevated in the highest part 1,444 feet above the sea, upon a length of about eight miles, with a breadth every where less than a mile, and generally less than half a mile. Within this narrow elongated area, the ridge swells into about 20 distinct summits, disposed in one or two longitudinal rows, and leaving between them hollows of sufficient depth to allow of steep roads and paths across the mountain. Six of these passes, deeper than the rest—viz. at the Wych between Great Malvern and Malvern Wells; above Little Malvern; between the Herefordshire Beacon and Swinyard Hill; between Swinyard Hill and Midsummer Hill; between Midsummer Hill and Raggedstone Hill; and between Raggedstone Hill and Keys-end Hill—allow of roads across from east to west; while at each end of the ridge other roads in the same direction serve to complete the connexion of the Vales of Herefordshire and Worcestershire, which the Malvern Hills naturally interrupt.*

The range considered as simple, rises higher and higher toward the

* Is the name Malvern derived from Moel Hafren (The Hill by the Severn)?



n of the Malvern Hills, as seen from the Vale of Severn.

of road in front of the hills are marked by continuous black lines.]

north, till near the extremity; but in fact there are two portions of the Malvern Hills, separated by the transverse pass of Wind's Point above Little Malvern, each of which rises and grows broader toward the north, the southern portion being crowned at its northern extremity by the mounds of the Herefordshire Beacon (1,162 feet above the sea), and the northern portion rising in the Worcestershire Beacon, to the height of 1,444 feet.

Commencing our survey at the southern extremity we find the lowest of all the Malvern Hills—the Keys-end Hill, a single irregular mound, rising out of a plain which is about 300 feet above the sea, to an elevation of 665 feet. Bounding this hill on the north is an obliquely traversing valley, at White-leaved Oak (460 feet above the sea) and beyond it rises the second considerable mass of Malvern Rocks, in a rough double crest called Raggedstone Hill, 884 feet above the sea. A second valley now crosses the mountain nearly at right-angles—at Holly-bush (600 feet above the sea), and beyond it swells a third rocky mass in a double ridge called Midsummer Hill, 1,006 feet high, crowned by the large and interesting mound of an ancient camp. A third valley (575 feet above the sea) crosses the ridge at Fair Oaks, and beyond it appears a single narrow ridge of syenite, granite, gneiss, &c., called Swinyard Hill, 946 feet high. It ends on the north in an attenuated point, and is succeeded by a narrow valley directed to the south east (875 feet high), over which towers up the great complicated mass of bold ground which bears the ancient and ample mounds of the Herefordshire Beacon, on the western summit, while a lower and more rugged hill, or rather a little group of rough hills, occupies a small tract on the east, making the ridge double, though not so regularly or equally as in Midsummer Hill and Raggedstone Hill. The highest point of the Herefordshire Beacon appears to be only 1,162 feet above the sea, but the grand form and favourable situation of this mountain make it one of the most conspicuous features of the Malvern Chain.*

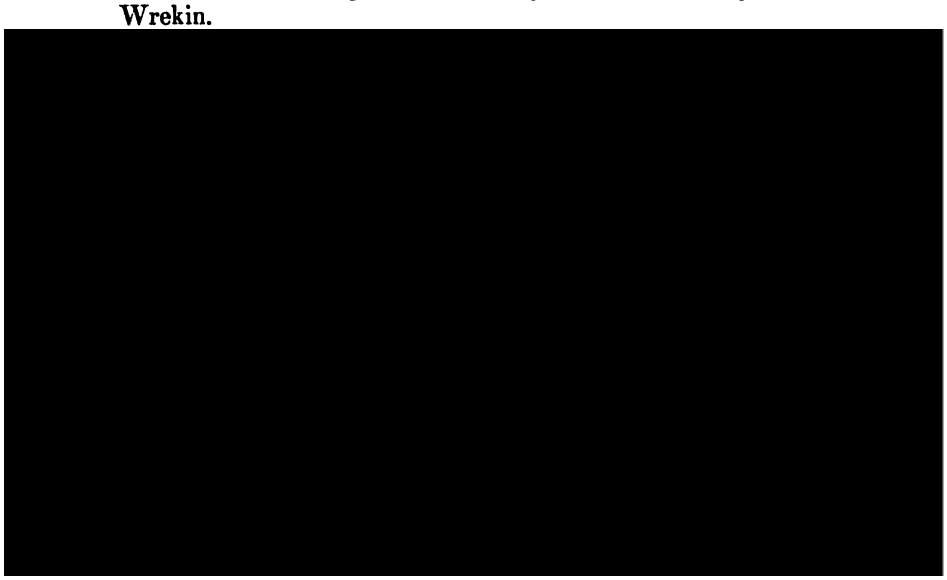
A sudden contraction of the range now takes place, and a narrow elevated pass, called Wind's Point, on the north side of the Herefordshire Beacon (830 feet above the sea), allows passage for the mail road to Ledbury. From this point towards the east descends a winding and partly woody valley to Little Malvern. And south of this is another short valley, so that this may be regarded as the most picturesque part of the Malverns, viewed on their eastern front. Beyond Wind's Point the Ridge contracts to only one quarter of a mile in width, but is marked

* Mr. Horner was misinformed as to this being the trigonometrical station of the Ordnance Survey; that was on the Worcestershire Beacon, which is about 280 feet higher, and is visible from Bardon, in Leicestershire.

by several obtusely conical peaks (one 1,224 feet high near Malvern Wells), and intervening depressions on its narrow crest, till we reach the deepest depression, called the Wych (900 feet above the sea). Beyond this the ridge rises rapidly higher and higher till the culminating point is reached on the rocky summit called the Worcestershire Beacon (1,444 feet above the sea), the trigonometrical station. Eight or more partial peaks may be counted from the north side of the Herefordshire Beacon, to and including the Worcestershire Beacon. North of the Worcestershire Beacon a great depression happens in the ridge, allowing paths to cross at two points, about 1,160 feet above the sea; the valleys from these little hollows unite before reaching Great Malvern, and leave a little to the south the short glen in which St. Ann's Well is situated under a rough buttress of the Beacon.

The width of the ridge now augments by addition to the eastern side. On the line of the Beacon continued to the north, are three not very remarkable peaks (that called Summer Hill being about 1,280 feet high), and east of these one great hill, called the North Hill, 1,366 feet high. The whole ridge is cut off on the north by an abrupt descent, on a line from north-west to south-east, and sinks into the general plain, which within half a mile of the hills is less than 300 feet above the sea.

The country which borders these hills is universally at a lower level for many miles around, so that from their summit the eye roves freely to the east over the wide vale of Severn, to the Lickey Hills, and the Cotswold Cliffs of Broadway and Cheltenham; to the south are seen May Hill and the Forest of Dean; on the west, beyond the rich woodlands of Herefordshire, appear the Skyrrydd, the Sugarloaf, and the Black Forest, the Steeps of the Blorenge, the Vans of Brecon, and the Peaks of the Berwyns; and the northern horizon is broken by the two Clee Hills, the ranges of Abberley and the solitary dome of the Wrekin.



tinguishing the red light which gilds those high summits after all the regions around them have sunk into obscurity.

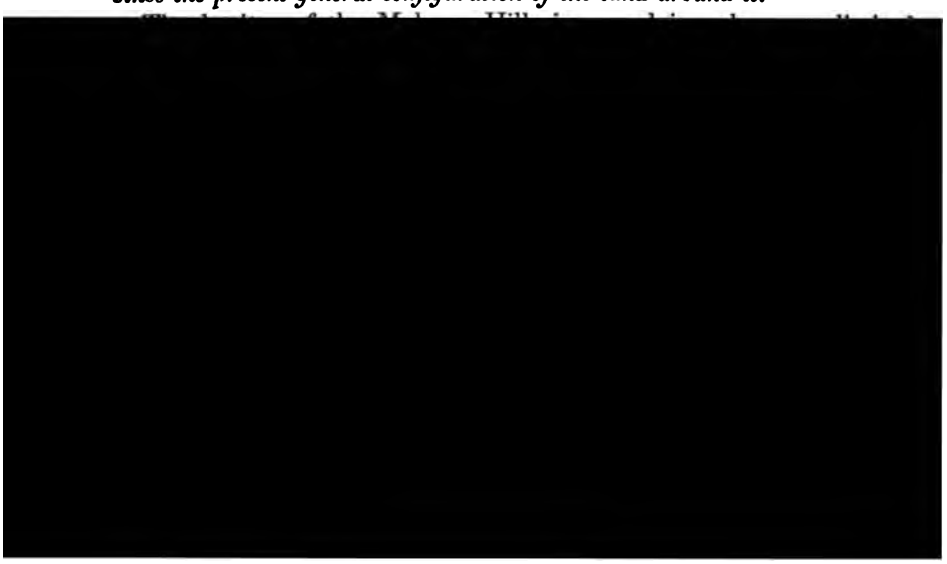
The Malvern Hills, where the aspect of nature has not been modified by cultivation or excavation, meet the lower grounds which surround them in grassy or mossy surfaces, sometimes varied by the gorse or furze or scattered hollies, but very rarely shaded by thick natural wood. Their slopes usually inclined from 25° to 30° are broken occasionally by long ridges or narrow mounds of rocks, and undulated by dry, smooth, or rocky hollows, which commence near the summit, but grow indistinct before reaching the lower ground, and there end so obscurely as to present no direct continuation of their channels.

The broad surfaces inclined from 25° to 30° are formed of detritus which has accumulated at this *angle of rest*, and become overgrown with vegetation; the smooth valleys are filled in like manner with such detritus, which is very unequal in depth, and when dug through shows irregular points and ridges of rock buried beneath the rubbish. This great accumulation of loosened matter is favoured by the facile decomposition and remarkably fissured state of the rocks of the Malvern Hills; it is most abundant on the eastern side, where the greatest difference of level appears between the plain and the mountain tops, and on that side the detritus may be traced for several miles into the plain. Where the slopes of detritus are extensive, as between Great and Little Malvern, they have tempted cultivation, and this has injured the picturesque effect of the ground. These sloping surfaces are least extensive where the hills cover the greatest width, as on the sides of the Herefordshire Beacon, Worcestershire Beacon, and North Hill. The uniform steep slopes, and the rough ridges and mounds of rock cease together at particular levels, on descending the sides of the Malvern Hills, but not at the same levels on the western and eastern sides. On the western side they cease at an elevation somewhat greater than that of the neighbouring low hills (900 feet), but on the eastern side are extended downwards to 600 or 500 feet above the sea. On this side therefore the Malvern Hills have their grandest effect when seen from a distance. This statement must, however, be understood with some explanations. The lines in question, where the steep slopes and rough rocks of the Malverns cease, are generally somewhat higher in the northern parts of the ridges, both on the eastern and western sides.

Below this line, which is here assumed to be the natural limit of the Malvern Ridge, the country on the east slopes away at moderate angles of inclination, usually about 5° or 10° (but sometimes for small breadths at higher angles), and thus easily joins the nearly plane ground of the Vale of Severn, but on the west the surface is extremely undulated

with hills and valleys, the irregularity being generally dependent on the unequal resistance which the different strata have offered to atmospheric action and the forces of water. On this side therefore the Malvern Ridge blends with the lesser hills into harmonious combinations of considerable and varied beauty; but from the Vale of Severn it rises abrupt and solitary, and owes to this cause more than to its absolute elevation, or the forms of its constituent peaks, the grand and remarkable effect which it produces in the landscape.

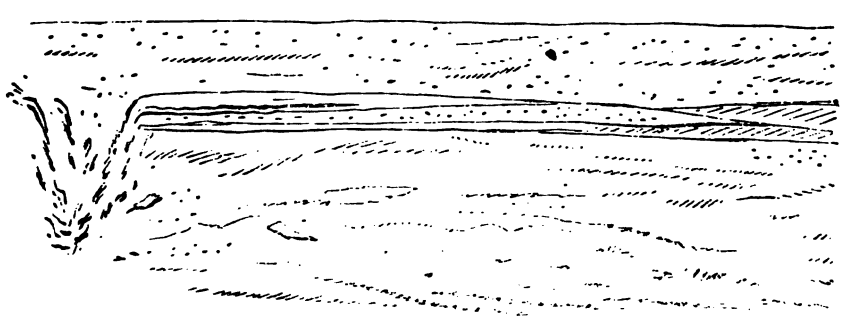
The detritus of the Malvern Hills is so abundantly spread over the plains on the east, as to suggest the inquiry how far the removal of this mass of matter has lowered the height of the hills. Assuming as the average breadth of this detrital covering four miles, the average depth of one foot (near the hills it is sometimes a few yards deep and but little mixed with earth), and taking the length at about eight miles, or nearly equal to that of the Malvern Hills (which is below the truth), we have about 32 square miles one foot deep. Now the area of the Malvern Rocks *in situ* may be about four miles square, and if we suppose the waste to have been uniform over their surface, this would give for the whole range a loss of eight feet in height. But perhaps a better supposition may be that the waste was in proportion to the elevation of the hills, and if we take this from the line of the detrital accumulation, we shall have the waste represented in the form of an attenuated sheath, 16 feet deep on the summits, and reduced to nothing at the foot of the steep slopes. To this we should add the bulk of matter removed in a finer state of disintegration, but of this, probably much larger amount, no satisfactory estimate can be formed. From these considerations, it would appear that the waste of the surface of the Malvern Hills cannot have greatly affected their form or elevation, *since the present general configuration of the land around it.*



as have been seen in many parts of Wales, and have been regarded as the effects of glacial movement on land, or of ice masses or rock fragments dragged by currents on the sea bed. The narrow surface of the Malverns, as well as their crested form, forbids the supposition of the formation of glaciers on them since they acquired their present general configuration. There are furrowed rocks, however, along the plane of a fault to be hereafter noticed; but this appearance is only revealed by the progress of deep excavations. It is not likely that under other circumstances any ancient surface marks can be discovered on the Malvern rocks; for they are so remarkably fissured and, as Mr. Horner has already explained, in part so rotten, that the natural processes of weathering have in most situations penetrated to a considerable depth, staining the surface with oxidated iron and disguising the original aspect of the rock.

The Malvern detritus may be recognised in some remarkable situations at considerable distances from the hills, as in Longdon field, south of Upton, on the lias and red marl, and more abundantly on the summit of one of the singular detached mounds of upper red marl, between Corse and Hartpury, called Limburg Hill. In each of these situations Caradoc sandstones, with fossils, as well as several syenitic fragments were gathered, and these detrital masses appeared to be in deposits separate from the ordinary gravel of the Vale of Severn, which, generally speaking, seems to occur in lower ground. (In this Severn gravel moss agates and jaspers occur round the base of Barrow Hill.) On Limburg Hill the Malvern detritus is remarkably abundant.

In the valley between Eastnor and Clincher's Mill is an interesting local accumulation of gravel, very rich in fragments from the neighbouring hills, mixed with red and yellow sands in irregular layers. The appearance is copied below.



About Colwell considerable deposits of gravel, partly derived from the neighbouring hills, cover with a thin veil the stratified rocks beneath; but, in general, accumulations of this nature on the western side of the

Malverns are of limited extent, and lie chiefly in peculiar hollows, so as to indicate only partial floods of local origin and limited extent. No trace of the northern drift (as the detritus transported from the Cumbrian lakes has been called) occurs in the region west of Malvern.

The Malvern Hills constitute a local summit of drainage, from which many small streams, mostly originating in springs, flow eastward through the plain to the Severn, and westward through deeper and more winding glens to Cradley Brook and Glynch Brook, the former a tributary of the Teme, and the latter a branch of the Leadon.

The surface of the hills is uniformly and excessively dry. The water which falls in rain sinks at once into the innumerable fissures of the rocks, and reappears in many springs, at or about the level where the steep slopes of the hills end and the Malvern rocks are covered by the strata of the lower ground. To this the most remarkable exceptions are the two celebrated springs of the Holy Well at Malvern Wells, and St. Ann's Well at Great Malvern. These, and a few other springs under the Worcestershire Beacon and at North Malvern, issue at levels considerably above the line already referred to. Some others issue below that line, and acquire, in consequence of passing through the strata and the detritus which covers them, properties corresponding to the nature of their subterranean channels. Hence, on the western side of the hills, where limestones abound, the springs contain carbonate of lime; and on the eastern side, which is much covered by decomposing trap based on red sandstones, chalybeate impregnations are not uncommon. In the low ground east of Little Malvern the bog iron ore which occurs in a few spots may be referred to this source, and at Great Malvern the celebrated chalybeate spring.

The following are some of the remarkable springs along the line of the Malvern Hills, with the levels at which they issue:—

On the Western Side. *In the midst of the Hills.* *On the Eastern Side.*

Malvern, varies from 50° (air at 30°) to 52° (air at 75°, W. A.). The chalybeate well near Great Malvern Church had a temp. of 50°, 15 December, 1845 (W. A.).*

The Holy Well and St. Ann's Well yield waters of very similar quality. The analyses of their waters, by Dr. Wilson, of Worcester, are given by Mr. Horner (Geol. Trans. i. p. 313); and he adds, from the qualitative tests of Dr. Marcet, a summary of the contents of Walm's Well. These results are collected below.

	Holy Well.	St. Ann's Well.	Walm's Well.
Grains of solid ingredients in one gallon	14·6109	7·395	12·
These consist of—			
Carbonate of soda. .	5·330	3·550	None?
,, lime. .	1·600	0·352	Principal ingredient.
,, magnesia	0·920	0·260	Minute quantity.
,, iron. .	0·625	0·328	
Sulphate of soda . .	2·896	1·480	Sulphate of soda.†
Muriate of soda . .	1·553	0·955	Muriate of magnesia.
Residuum	1·687	0·470	

The agricultural character of the hills is simple. They afford everywhere herbage for sheep, and on the smooth slopes cultivation is practicable by hand labour. Even on the top of one of the north hills, 1200 feet above the sea, the plough is used. The soil is apparently not so rich as in some other trap districts, nor does the stony detritus which is spread about the base of the hills improve the natural fertility of the red sandstones and marls. In some degree the prevalence of this detritus may be accounted a cause of so much of the surface on the eastern side of the Malverns being suffered to remain in the state of unenclosed land. Perhaps the great proportion of silica in the composition of the Malvern rocks renders the soil which they yield less fertile than that which often results from the decomposition of trap.

The climate of the Malvern Hills offers several points of interest which have been as yet insufficiently examined. That the winds are

* The observations marked (W. A.) are furnished by the Registers of Wm. Addison, Esq., F.L.S.

† Dr. Marcet thinks it probable the sulphuric acid is combined with soda, and the muriatic acid with magnesia. The abundant carbonate of lime in the Walm's Well water may be accounted for from its place of issue being on the line of junction of the calcareous Silurian strata with the trap rocks.

Mr. Addison (Medical and Surgical Transactions, vol. iv.) states, from his own experiments, that the water of St. Ann's Well contains only three grains of solid matter, and that these consist of muriate of magnesia, muriate of soda, sulphate of magnesia, and sulphate of lime, with a little siliceous matter. No carbonates and no carbonic acid were detected. Three-fourths of a cubic inch of atmospheric air was given off from a quart of water.

It appears from all the experiments that the most decided character of the Malvern waters is their purity.

greatly influenced in local direction and in force by this narrow wall of elevated rocks, is matter of daily observation. As might be supposed, strong winds blowing from the west are often quite unfelt by the residents of Great Malvern on the eastern slope, while at North Malvern their ordinary force is augmented by the horizontal contraction of the stream of air. But a more singular thing is the calm which the former village frequently experiences with the wind blowing from the east, which on the plain may be strong, on the mountain ridge violent, and yet near the foot of the steep slope comparatively gentle. These effects depend on the steepness of the front of the hills; for these act in deflecting the currents nearly as houses are known to do.

The height of clouds passing over the Malvern Hills might be made matter of curious speculation, if compared with the amount of wind and the hygrometrical state of the air. In a few measurements during the very dry summer of 1844, I found several layers of clouds moving about twenty miles an hour, at elevations of 1800, 2400, and 8000 feet.

Remarkable effects of mirage have been seen several times by spectators regarding the great Vale of Severn in the direction of Bromsgrove; but the state of the atmosphere was not recorded by instruments.

The quantity of rain falling on the summit and the opposite sides of the Malvern ridge would be a very interesting subject of inquiry, which has not, however, yet been commenced. The pressure, temperature, moisture, and prevalent winds, have been accurately registered by William Addison, Esq., F.L.S., resident at Great Malvern, for the years 1835, 1836, 1837, 1838; and from his observations the following table is extracted:—

Height of Station above the Sea about 515 feet.

	1835.	1836.	1837.	1838.	Mean of 4 years.

have scarcely been injured. The botany of the Malvern Hills offers not much of obvious peculiarity, except in the cryptogamic families, which have been recently illustrated in a work by Mr. Lees. Mr. Addison gives a list of the Malvern plants in his Essay on the Medical Topography of the district.

The natural limit and line of defence offered by these hills has been further strengthened by art. Along a great part of the range runs the boundary of Worcestershire and Herefordshire, marked by a trench and mound which extend still further to the north. On the Herefordshire Beacon and Midsummer Hill are the extensive earth works of ancient camps.

Table of approximate Elevations of the Malvern Hills, determined trigonometrically from a base measured on Welland Common, 1842.

	Feet.	On what Authority.
Worcester Beacon	1444	Trig. Survey of Great Britain.
North Hill (east)	1366	The Geological Survey, 1842.
Point north of the Wych	950	Ditto.
High Point (Beacon), above Malvern Wells	1224	Ditto.
Hill north of Wind's Point	902	Ditto.
Hereford Beacon	1162	Ditto.
Swinyard Hill	946	Ditto.
Midsummer Hill (western point)	1006	Ditto.
Raggedstone Hill	884	Ditto.
Keys-end Hill	665	Ditto.

Table of approximate Elevations, around the Malvern Hills, determined trigonometrically by comparison with the Worcestershire Beacon, assumed to be 1,444 *feet high.*

	Feet.
Hill north of Bank Farm	852
Hill west of ditto	782
Hill south of ditto	729
Bank Farm-house	640
Croft Farm	798
Rose Farm	403
Hill north of ditto	723
Hall Court	433
Hill south-east of ditto	688
Mathon Church-top	384
Colwell Church-top	423
Mathon Lodge	684
Obelisk in Eastnor Park	824
Dog Hill, near Ledbury	822
Woodbury Camp (Abberley District)	975
Summit of Old Storridge (The Beck)	732
Link Farm, near Great Malvern	281
Malvern Church-top	605

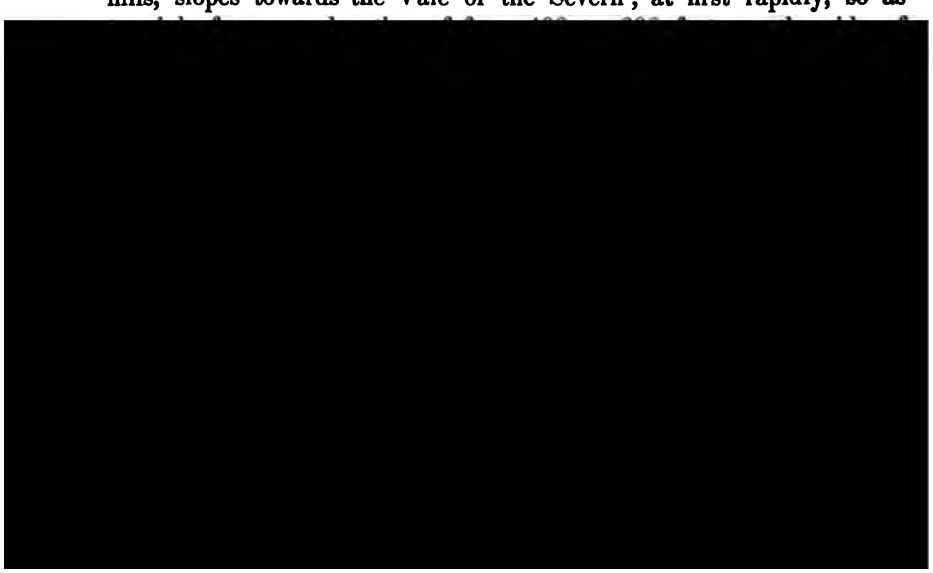
Table of approximate Elevations in and around the Malvern Hills, determined barometrically by comparison with the Worcestershire Beacon, assumed to be 1,444 *feet high.*

	Feet.
North Hill (east)	1361
Ditto (west)	1285
Ditto (north-west)	1154
Sugar-loaf Hill	1169
Pass between it and the North Hill	1151
St. Ann's Well	815
Belle-Vue Hotel	550
Dowlas New Church	887
Summit of road from it to North Malvern	931
Highest point of the Caradoc sandstone below Worcester Beacon	944
Hill S. W. of Cowley-Park Farm (conglomerate)	811
Holy Well at Malvern Wells	740
Walm's Well	755
Tree near a cave on the east side of the Hereford Beacon	915
"Silurian Pass" at the north end of the Swinyard Hill	817

COUNTRY SURROUNDING THE MALVERN HILLS.

The Malvern Hills, strictly so called, have now been described; but it is one of the characteristics of this range to stand in natural association with a considerable mass of undulated ground, on the west and on the north, which appears to have undergone elevation along with the Malvern Rocks, and to have participated with them in a long course of geological accidents. On this account, and for the sake of preserving unity in the geological descriptions which follow, it is convenient now to add a short notice of the principal features of the country surrounding the Malvern Chain.

As already observed, the whole region lying on the east of these hills, slopes towards the Vale of the Severn; at first rapidly, so as

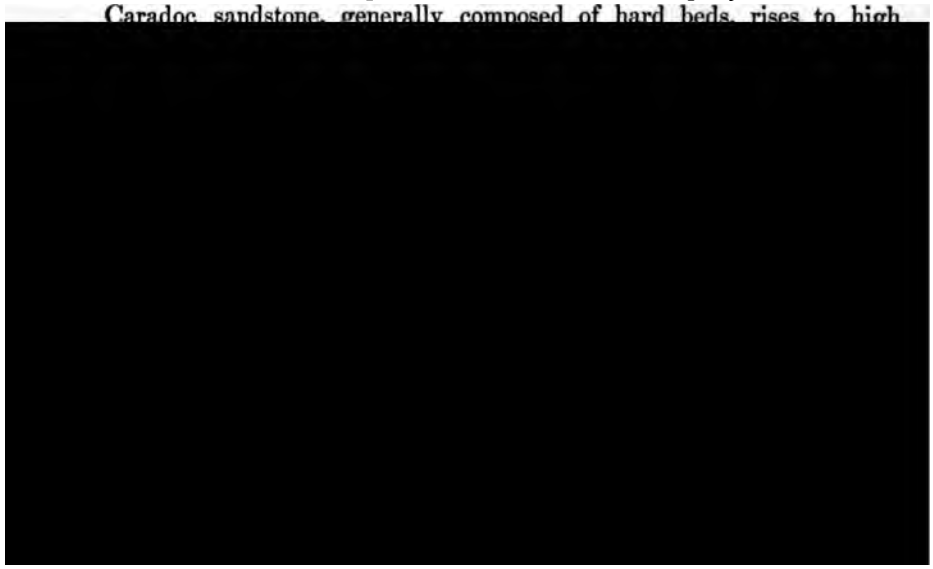


From the North.

The Malvern and Ledbury Hills, as seen from a part of the Abberley range.

the district farther south the highest point near the hills is 824 feet (Obelisk in Eastnor Park), and the highest point distant from the hills is 822 feet (Dog Hill, near Ledbury). The area occupied by this undulated district is very much greater than that of the Malverns, but its irregular figure admits of description by reference to their several summits. West of the Keys-end, Raggedstone, Midsummer, and Herefordshire-Beacon Hills, a breadth of three miles is covered by the hilly districts of Eastnor, Ledbury, and Hope End; from the Hereford Beacon to the Worcester Beacon the breadth of the same flanking region is contracted to less than three-quarters of a mile, and in two places to less than half a mile; but opposite the Worcester Beacon it expands to about one mile and a half, and so continues to the northward. In this direction it extends altogether about five miles beyond the northern extremity of the Malvern Hills, and then, contracting to a point, ceases and subsides beneath the valley of the Teme, at an elevation of about 180 feet above the sea.

The interior of this lateral district, if we may so term it, of the Malvern Hills, is remarkably undulated; not, however, by the erosion of river-channels, but by a general process of denudation, which, with but slight relation to stream-courses, has degraded the soft strata, and left prominent the harder rocks. In this district the hard and soft rocks occur in frequent alternations, and thus constitute many parallel hills and vales, running in straight or very sinuous courses, not according to any water-channel, but according to the great flexures into which the whole mass of the stratification has been bent and upheaved. On the map this peculiarity may be traced by the eye, merely observing that the stronger blue tints, which represent limestone, generally mark ridges of ground either absolutely high or relatively prominent, from amidst the broader depressions of shales more lightly tinted. The Caradoc sandstone, generally composed of hard beds, rises to high



Rock, and the more solid Wenlock Limestone. Of these, the first-mentioned rises almost universally to the highest ground, but the latter makes the most continuous elevations. Both are, however, crossed by many small hollows and glens, not always yielding passage to streams, and frequently so circumstanced as to appear rather to have been marked out for easy erosion, as lines of weakness, by deficient deposition or unequal displacement of the beds, than to have been scooped out by mere watery violence.

The outcrop edges of the limestone ridges are very generally left in their naturally woody state, as the steepness of the slopes (often amounting to 20° or 30°) of these edges renders cultivation difficult, and from the easy sliding away of the soil unprofitable.

Springs of water are frequent in this district, along the lines of the limestones, but from the small surfaces which these occupy, they are not very copious. They are generally somewhat charged with carbonate of lime, which, after exposure to the air, falls, but seldom in sufficient quantity to accumulate considerable masses of tufa.

Some depositions of this nature happen in the country between Eastnor and Colwall. There are no mineral waters in the district. Ponds are frequently resorted to in the broad argillaceous vales which intervene between the limestone hills. Is goître more frequent in this district of calcareous waters than in other parts of the neighbouring country?

Beyond the district thus characterized, extend farther to the west great breadths of more level country, containing strata of old red sandstone, and uniting with more extensive areas of similar deposits, which it is not necessary at present to notice.

We may now describe the distribution of the rocks in the several hills, and their relations to the surrounding strata.

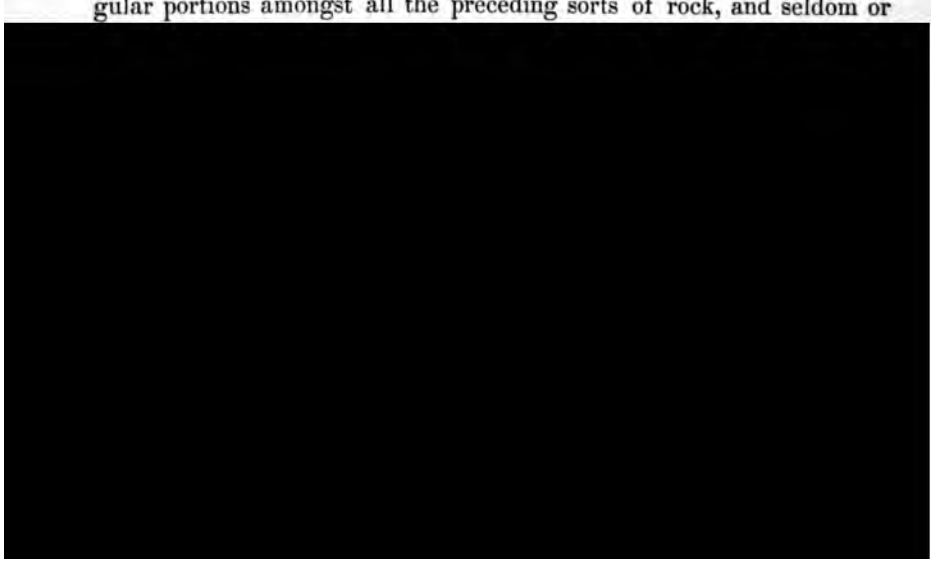
KEYS-END HILL.*

Commencing our survey at the southern extremity of the Malvern chain, we find the country surrounding the Keys-end Hill to offer four sorts of stratified rocks, all lying on lower levels than even this, which is the least elevated hill of the whole Malvern range. On the east and south-east we find red marls, slightly spotted or banded with greenish blue, and slightly varied by white bands, or irregular threads and plates of gypsum. On the south, in Bromsberrow Park, is a bright red, loosely aggregated sandstone; on the south-west, a band of purple

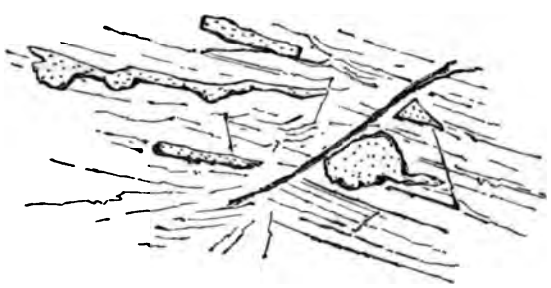
* The name of this hill (identical with that of 'Casend,' in the vicinity) seems to contain the Gaelic element 'Cas' (steep).

or brown-red aggregated, brecciated, or conglomerate rock, in which fragments of rock, the waste of the Malvern Hills, are mixed with sandstones from their western flanks. These three red stratified masses are classed in the new red formation, the lowest member of the Triassic system of the German nomenclators. On the west, rising from beneath the brown-red conglomerate, are strata of laminated red or gray shales and sandstones, locally varied by conglomerate grits, the Caradoc formation of Mr. Murchison. In Howler's Heath these abound, and yield abundance of organic remains. Finally, against the north-west and north slopes of the Keys-end Hill, and mingled with some small ridges and knolls of rock which (geographically at least) seem to be continuations from it toward the north-west, we find black or white shales, and some sandstones containing felspathic and other grains, —volcanic sandstones, as they have been termed. Close to trap bosses, which appear to run out from the Keys-end Hill, these shales are usually white; at a greater distance, black. Neither they nor the sandstones manifest any remarkable induration near the trap of the hills, nor is any such thing observable in respect of the brown-red conglomerate, the bright red sandstone, or the red and green marls. Actual junctions of the stratified, and trappean rocks, are, however, seldom seen.

The Keys-end Hill itself consists chiefly of ill-characterized syenitic rocks, which seem to be rudely bedded, but are really composed of irregular, even ramified, masses of a red mixture of felspar and quartz, and a dark green hornblende. Sometimes these felspatho-hornblendic compounds appear brecciated; often, for short distances, laminated; and when containing mica might, in hand specimens, be regarded as of the nature of gneiss or micaceous schist. Veins, or insulated masses of felspathic rocks, and felspar and quartz, lie in limited, tortuous, and irregular portions amongst all the preceding sorts of rock, and seldom or



Regarded in a general light, these rocks are all of igneous origin; the arrangement of the mineral constituents is the fruit of very peculiar and seemingly disturbed segregations; and the structural arrangement of the masses seems to indicate frequent internal displacements after consolidation, and perhaps external strains or local pressures during the consolidation. Hence the rocks offer massive, laminar slickenside, and some brecciated structures, the basis being felspar and hornblende, with, in particular situations, mica. The slipped surfaces are (as usual in these hills) glazed over by crushed hornblende, and the joints are often impurpled by oxide of iron. There is perhaps somewhat of an eastward dip to be frequently seen in the laminated rocks, but these appearances melt away or terminate suddenly in the usual veinlike segregations or interramified masses of quartzo-felspathic and felspatho-hornblendic rock, which can hardly be called syenite.



Bedded structures in the Trap of Keys-end Hill.

From near the north-western side of this hill run out several short lines of trappean protuberances, generally directed toward the north-west, and broken into narrow, elliptical, or almost circular bosses, rising above the surrounding surface, which is partly formed of black shales (whitened near the trap) and partly of greenish sandstones (volcanic grit of Mr. Murchison). Ten or more of these bosses, apparently connected below the surface, may be counted between the Keys-end Hill and Rowick, all occurring in comparatively low ground, under the outcrop of the Caradoc sandstone in Howler's Heath. Extensive quarries near the south extremity of this hill lay open its structure, and contribute to the supply of rough building and road stone for the neighbouring country.

VALLEY BETWEEN THE KEYS-END HILL AND RAGGEDSTONE HILL.

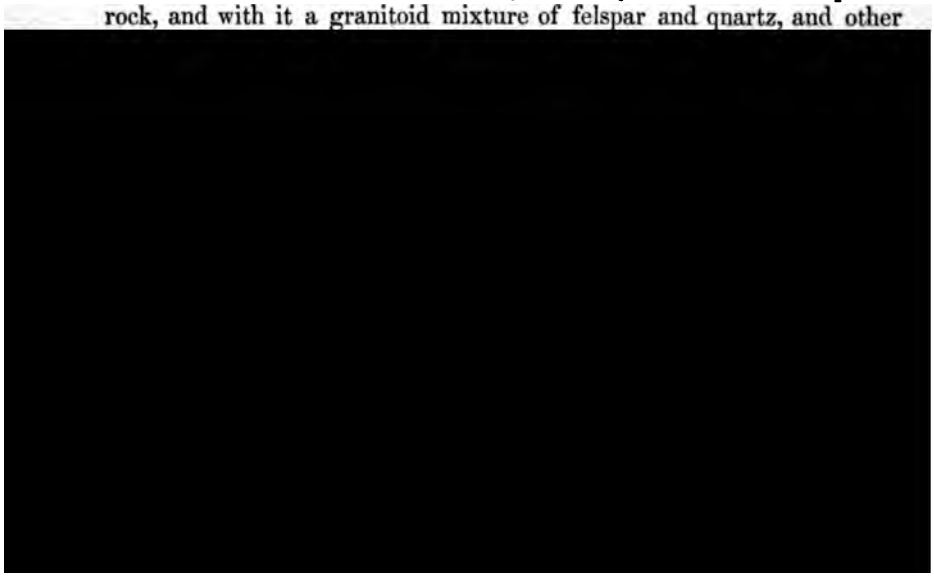
This deep narrow gorge, cut entirely through the Malvern range, in a direction from north-west to south-east, is filled up by black shales and sandstones, which apparently break the continuity of the trappean

rocks. In these black shales occur myriads of very small Trilobites, but in only a few limited situations near the Whiteleaved Oak. They are such as belong to no other strata in this district.

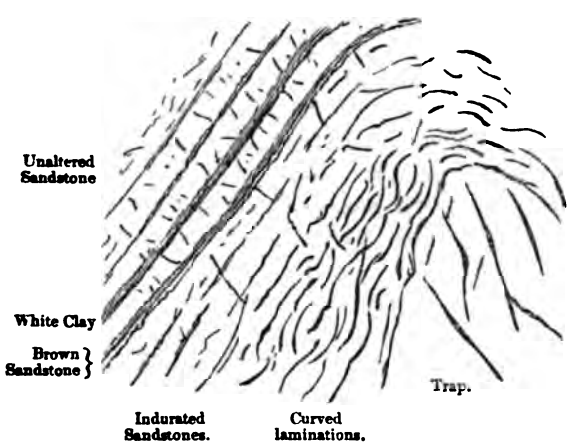
THE RAGGEDSTONE HILL.

The picturesque mass of rocks called the Raggedstone is formed in two summits of nearly equal elevation; the western and highest being 884 feet above the sea. From between them a deep and singular valley is scooped out to the south, and afterwards turns eastward. The rocks on the western side of the hill, almost to its apex, are mostly sandstone, partly laminated and micaceous, but generally greenish, irregularly bedded, and of the character termed volcanic. Occasionally these gritty rocks assume very much of a trappean aspect, and are otherwise modified, so that the limit between them and the true trap of the hill is obscure. At the south end of the hill they are found, ranging N. 15° W., and dipping W. 60°, and in places appear arching over to the east, being supported on irregular bosses of felspathic trap. In the most southern quarry of the hill, contorted gray schists appear, irregularly associated with the igneous rock. Round the north end the sandstones spread, and assume in places a hard conglomeritic character, with pebbles of red felspar and quartz.

The eastern part of Raggedstone Hill is composed of various rocks, amongst which a fine-grained, laminated, felspathic rock, sometimes having the aspect of flinty slate, abounds, and makes ridges, which cross the hill obliquely, from W. to E., or S.W. to N.E. Alternating with this compact felspathic rock, is a limited exhibition of schist, with silvery mica, and the masses are interrupted by a peculiar serpentinous trap. At the N.E. end of the hill is a very mixed syenitic rock, or felspathic rock, and with it a granitoid mixture of felspar and quartz, and other



southern part of the West Raggedstone and the northern part of the East Raggedstone, the usual rich felspathic red syenites occur, and in the northern part some dark, small-grained, crystallized syenite appears; but nearly all the upper parts of these hills are principally composed of quartzo-felspathic rocks, very slightly and indistinctly crystallized, more or less of a laminar structure, often bleached or flesh-coloured on the surface. This rock runs much in ridges, and it is associated or intermingled with a sort of greenstone or serpentinous trap, more or less laminated and partially veined. Such rocks also appear, especially the compact felspars, in the West Raggedstone, and there support the mass of lower Silurian strata of sandstone and shale dipping westward. These strata are altered, indurated, and apparently changed in composition. In descending the ridge from the summit toward the south, we may observe the felspathic and venigenous trap subjacent to all the strata; the summit is formed of a laminated micaceous rock, with, in selected specimens, twisted laminæ; lower down a kind of imperfect hornblende schist (schalstein); and above and exterior to them all, the usual micaceous laminated, greenish sandstone, quite unaltered in appearance. These indications of metamorphism are continued to the very end of the hill. Its southern extremity runs out in a long narrow tongue, with a central axis of red felspathic trap, over which, appearing like exfoliations from it, are schistose rocks, in arched and twisted masses; farther off from the trap appear, highly indurated, dark, and trappean in aspect, the altered volcanic sandstones, with confused joints; and above these, the sandstones regularly bedded and laminated, with fucoidal impressions, and otherwise quite unaltered. The thickness of the rocks through which any of these changes can be traced does not exceed fifty feet.

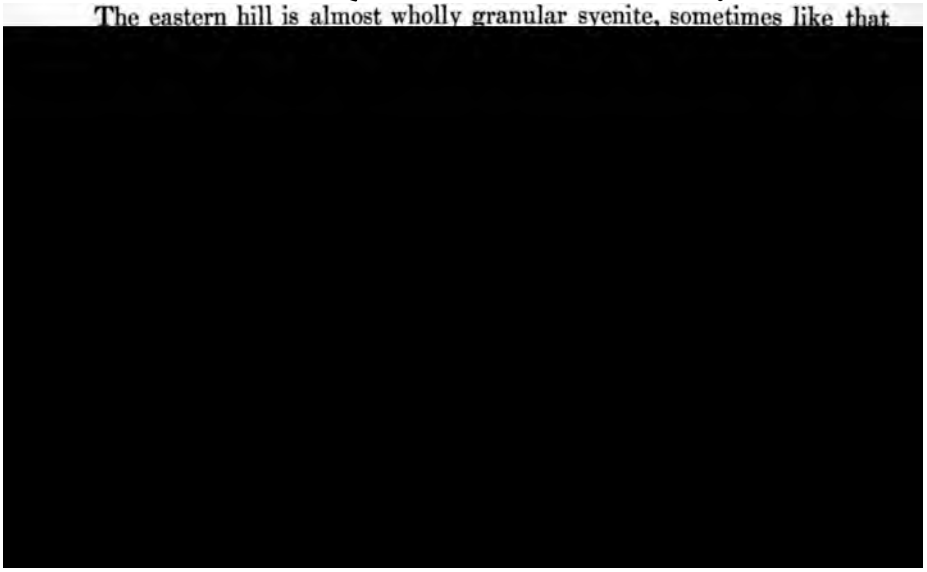


THE HOLLY-BUSH VALLEY.

Here the trap ridges are deeply cut but not entirely divided by a transverse narrow belt of sandstone, of various character, and wearing often a trappean, and sometimes a conglomeritic aspect. It generally dips toward the west, and is extensively cut through and quarried on the London road, west of the hills. Here it is in many beds, some thick and others thinly laminated, amounting altogether to several hundred feet in thickness. No fossils except obscure traces of fucoids have been observed in the beds. Great dykes of felspathic trap traverse the sandstones, one of which may be well studied in a quarry on the north side of the road, included in the peculiar sandstone already alluded to.

MIDSUMMER HILL.

On the west side of this fine hill gray sandstones occupy the slopes and turn round the extremities, generally dipping away from the hill and being partially (especially on the N.W. face) conglomeritic. In the conglomerate are quartz and red felspar fragments, as in the coarse beds of Howler's Heath. The great mass of the hill is syenite, of a reddish colour; seldom exhibiting such appearance of bedding as the rocks of Keys-end Hill, though sometimes the felspar and hornblende, or felspar, hornblende, and mica, are so arranged as to produce vertical lamination. It is difficult in that case to refuse to the rock the title of gneiss. A frequent component of this hill is hornblendic trap, with red felspar in laminæ and cross veins, and, in places, rocks principally composed of laminated hornblende appear. In following round the magnificent outline of the British camp, all these varieties of rock may be examined. The eastern hill is almost wholly granular syenite, sometimes like that



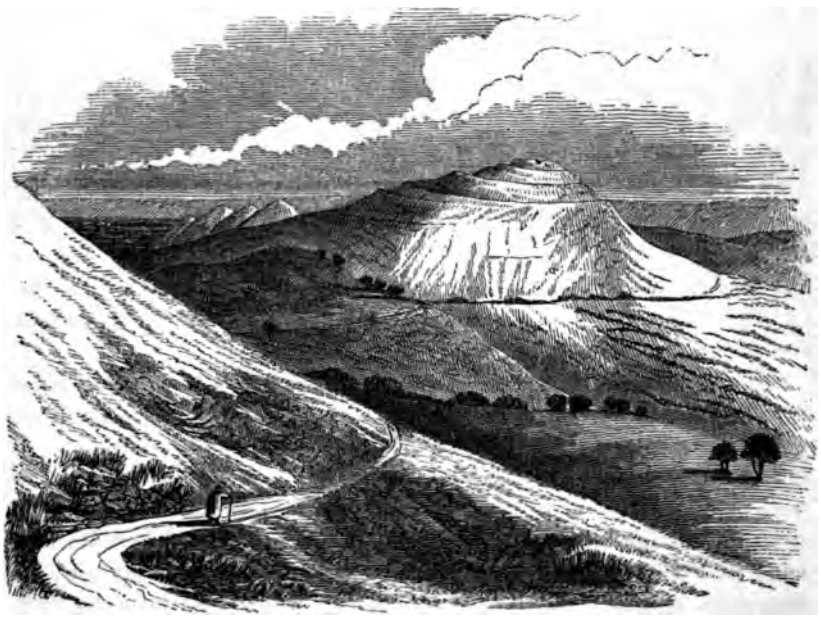
GULLET-WOOD VALLEY.

The road and hill sides show beds of a syenitic composition, but of bedded or even gneissic structure on the eastern side of the axis of the chain, dipping S.E. On the other side sandstones and conglomeritic beds appear in much confusion, often vertical, and dipping S. or N., according to the locality. The axis of the chain is syenite, in a very narrow band.

SWINYARD HILL.

This very narrow single ridge, interposed between wider and double ranges, shows a considerable variety of rocks, amongst which, however, none can be compared to the compact felspars of Raggedstone, but all may be classed as syenitic and granitic compounds, in which laminar, as well as granular and crystalline aggregations prevail. The southern extremity of the hill shows the usual imperfectly-bedded syenite, with local patches of richly hornblendic or richly felspathic segregations. Specimens may here be selected resembling the rock of Keys-end Hill, the North Hill syenite, and the felspathic stone of Scale Force. Advancing toward the central part of the ridge, laminar structures prevail, and banded rocks of hornblende (often crystallized) and felspar run across the ridge, in lines nearly east and west. Diversifying these are granular mixtures of the same minerals, resembling the rocks of North Hill; and others full of light green veins, like the epidotic syenite of North End; while amongst them all are patches and veins of felspar, holding a little quartz, and sometimes mica, and presenting large crystallized faces. These are remarkably abundant in the extreme northern part of the hill, where rarely quartz and mica appear in small veins, the mica lying on the walls of the vein, with its planes perpendicular thereto. There can remain no doubt on the mind of an observer that all these various aspects of the hornblendo-felspathic rocks are due to the influence of peculiar circumstances in their consolidation.

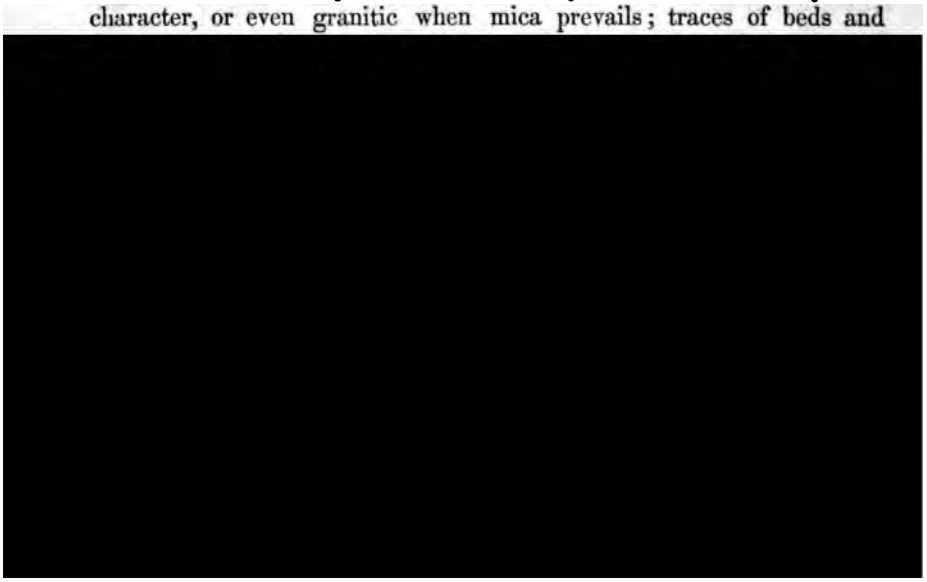
On both sides of this hill are Silurian strata, and between it and the Herefordshire Beacon, sunk in a little hollow, is a small patch of the same rocks. To this point, where a bad road crosses the ridge from Walm's Well, I give the name of Silurian Pass.



The Hereford Beacon, from the North.

HEREFORDSHIRE BEACON.

This huge mass of rocks occupies a greater breadth than any other part of the Malvern Chain, and exhibits a considerable variety of mineral composition or rather of aggregation. The western ridge, which is the highest and bears the great camp with its many trenches, is the continuation of the true syenitic axis of Swinyard Hill, and is of syenitic character, or even granitic when mica prevails; traces of beds and



organic origin. This eastern part of the Beacon Hill is more like the eastern part of the Raggedstone, in its mineral structure, than any other portion of the Malvern Chain. In all the upper parts the uncrystallized felspars and serpentinous traps abound in both these hills, and in both form ridges, across or oblique to the axis; but in each the extremities of the hills show traces of the usual syenitic rocks below.

On the western side of this hill the strata are pressed up against it, and much disturbed, but actual contact of them with the syenite is nowhere visible, on account of the abundance of detritus. On the eastern side the Caradoc sandstone passes over the neck of land of Wind's Point for a short distance. At the foot of the hill on the eastern side, white sandstones appear in the new red series.

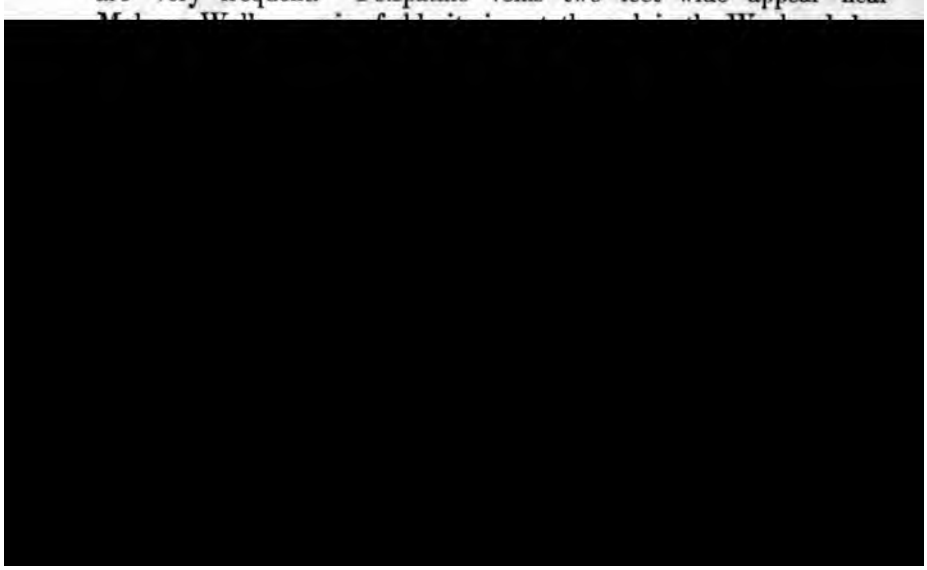
From near Gold Pits, looking southward.

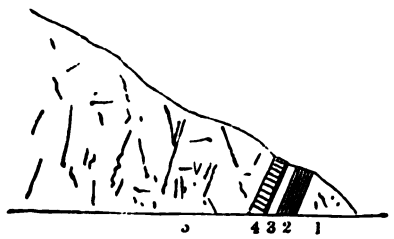
BETWEEN THE HEREFORD BEACON AND THE WORCESTER BEACON.

At Wind's Point where the Ledbury road crosses the Malvern Hills is a large quarry, where imperfect stratification appears in the mixture of felspar, quartz, mica and hornblende; irregular laminæ, veins, lumps and ramified masses of red felspar, quartz, and what must be called granite, abound. The beds are more or less undulated and even twisted, but generally dip northwards (N. E. or N. W.) about 30°. Joints

ranging nearly east and west cross these beds, and are lined by much carbonate of lime, some quartz, and a little sulphate of barytes. Slickenside surfaces indicate motion in various directions, and some of the fissures are somewhat venigenous; masses of mica, hornblende and felspar, may be picked up almost unmixed with other ingredients, and the degrees of their admixture are endless. There is no great felspar dyke or granite vein, but the masses of these substances are large and irregularly mixed with the bedded hornblendic rock. In the descent of the road toward Little Malvern, a few seeming dykes occur, and laminated gneissic and hornblendic masses are seen dipping in various directions. Proceeding along the summit we find in almost every ridge and hollow some fresh combination of the felspathic, quartzose, hornblendic, and micaceous elements which make up the endless varieties of the Malvern rocks. In a few places epidote veins are traceable. A cone of red felspar is followed by a hollow full of hornblende slate, the laminæ dipping east, with veins of epidotic syenite or even granite, and quartz; and this succeeded by mounds of richly hornblendic crystallized syenite, and a mottled mixture of red felspar and gray quartz.

Farther on syenites, massive and slaty; crystallized granular and slaty hornblendes; then a more or less micaceous slaty rock, which may be called gneiss, mixed with veins and masses of every shape of hornblende, felspar and quartz. The gneissic beds sometimes dip east 20° to 90°, and often appear to cross the axis of the mountains, in ridges directed to the N. N. E. between Malvern Wells and the Wych. Syenites red and green, with abundance of pure felspar and pure hornblende, appear about Malvern Wells. South of the Wych the gneissic beds are frequent, and dip to the S. S. E. and E. mixed with syenites, and felspathic masses and lumps. Appearances of veins in these hills are very frequent. Felspathic veins two feet wide appear near





1. Red syenite; 2. Dark hornblendic band; 3. Red syenite; 4. Chlorite vein, with soft decomposed felspar; 5. Red syenite.

On the western side of this part of the chain the Lower Silurian Strata come nearly close up to the trap, but their actual contact is not seen except in the Wych, where the artificial cutting has exposed a singular case of an apparently included mass of Caradoc sandstone and shale (soft and unaltered by heat) close to a little spring.

On the eastern side the new red sandstone is but imperfectly traceable, from its appearing in the roads south of Little Malvern to its exposure in the roads north of Great Malvern turnpike.

WORCESTERSHIRE BEACON.

In this great hill the rocks are in some parts large-grained granite; elsewhere a binary mixture of felspar and quartz; in other places true large-grained syenite, or fine-grained hornblende rock, and the admixtures of these varieties are frequent and sudden. Across the ridge between the Beacon and the Wych, runs a sort of vein of mica, giving origin to the only even supposed mine in the Malverns, but that a gold mine!* Such soft bands or veins of mica are not unfrequently seen between the Wych and Malvern, on the line of the new road. On that line of road the various composition of the eastern side of the hill may be examined with ease. Syenitic compounds, with hornblende bands or dykes, and quartzose, felspathic and granitic ramifications, are succeeded by laminated often very micaceous rocks, and these in some cases are so remarkably bedded and regular (near the turnpike) as to suggest to every observer the notion of their stratified origin and metamorphic state. In these schistose masses hornblende sometimes replaces the silvery or golden mica. Besides these varieties some angular brecciated trap occurs, mostly or near the very surface of the rocky masses, and apparently connected with the lines of their movement—a conclusion to which attention will be again called. In the hill

* I found no metallic products here except traces of iron pyrites. Copper ore has formerly been seen in small quantity by Mr. Horner and Mr. Conybeare.

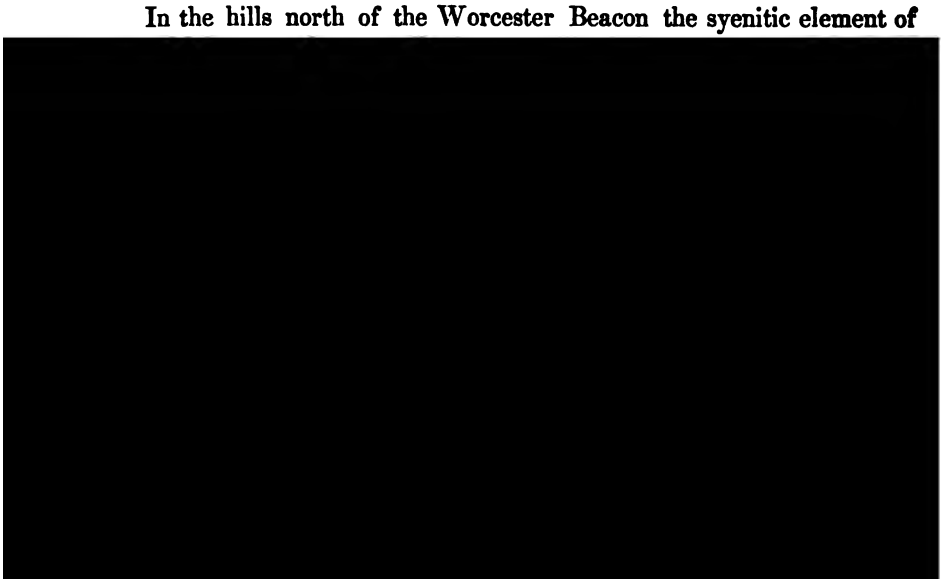
is the abundance of quartzo-felspathic veins more remarkable, than in the Worcester Beacon, and the crystallization of felspar is on so large a scale as to give plane faces of several inches in breadth. Almost graphic granite is produced by the arrangement of the quartz crystals in the felspar.

On the western side of the Worcestershire Beacon, Silurian strata come up to contact with the syenite, on the side of the little rill. On the north side of this small stream the trap has been long exposed by excavations for the road, and here we were so fortunate as to discover *in situ* the shelly conglomerate which had been found loose on the hill above at various points. It was discovered lying in a vertical band, against the syenite, full of pebbles and fragments of the syenite, quartzo-felspathic, and other rocks common in the hills above; and amongst these pebbles and chips, in their interstices, and cemented together by finer particles derived from the same origin, were plenty of the usual corals, crinoidea and shells of the lower Silurian rocks. The corals, shells, &c. were unaltered, and no peculiar sign indicated that the conglomerate had ever been subject to great heat since its deposition, while the presence of pebbles and chips of the pyrogenous Malvern rocks showed clearly the fact that these had been consolidated at *some period anterior* to the formation of the lowest Silurian beds (a part of the Caradoc sandstone, but not the lowest part) there visible.

On the eastern side of the hill the new red sandstone (white and red) appears at the level of Great Malvern, north and south of the village, under a considerable angle of inclination from the hill.

THE NORTH HILLS.

In the hills north of the Worcester Beacon the syenitic element of



From the Worcester Beacon, looking northward.

ν Clee Hills. γ Wrekin. β_γ Abberley Hills. 3 North Hill.

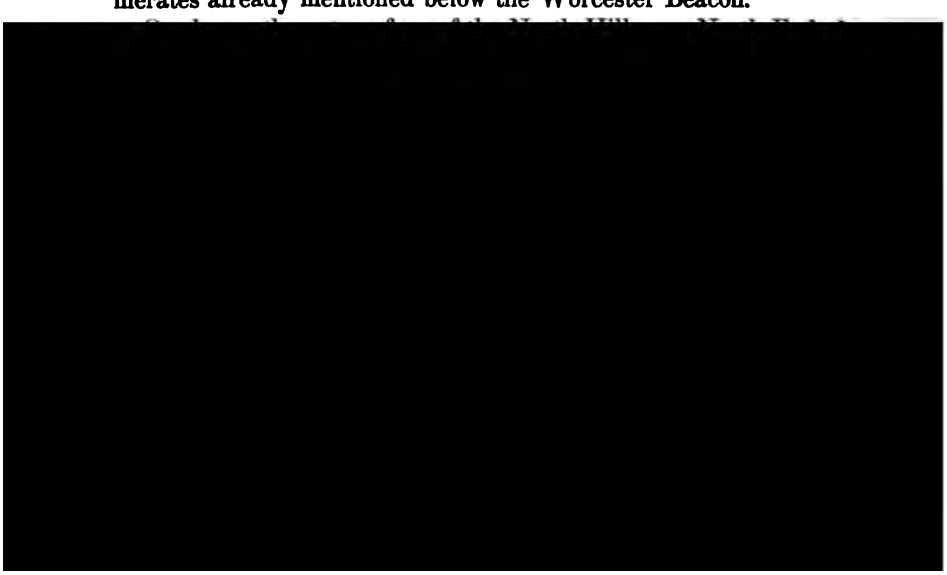
being often a fine pale red, and the hornblende very dark, this rock is occasionally very beautiful. Another and perhaps fully as abundant rock is extremely full of reddish felspar, with much quartz, and far less hornblende. It is occasionally epidotic, as at North Malvern, and much traversed by veins and varied by irregular proportions of the constituent minerals, and shows some tendency to tabular and bedded structures, as at North Malvern, and in the valley between the North Hill and the Worcester Beacon.

This rock forms the little bosses of trap which appear in the lower ground north of the Malvern Chain, and in one point on the line of the Abberley Hills. It is in fact one of the most abundant of the Malvern rocks, being of the same general character as the Keys-end syenite, which is scarcely absent from any of the Malvern Hills. A third constituent of the North Hills is a merely hornblendic mass usually fine-grained, and not unfrequently in juxtaposition with portions very rich in felspar, a relative position which doubtless is consistent with the origin of each in segregation of the minerals from the same fused mass.

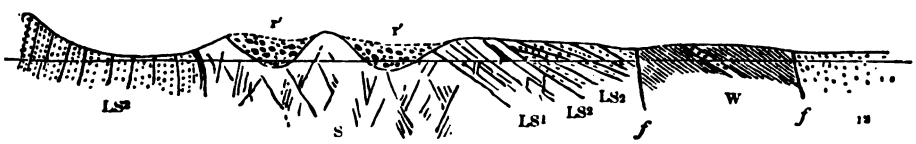
The north-eastern face of the hills is nearly a straight line from

N. W. to S. E. and is clearly on the line of a great fault which continues visible to the N. N. W. It causes a very sudden depression of the Malvern rocks, and farther to the north an abrupt line of truncation of the Silurians. These rocks are met but not covered by the new red marls, but the Malvern rocks are margined by detritus on the N. E. face of North Hill. Along the fault line the Malvern rocks show a considerable quantity of that singular brecciated trap which might be mistaken for conglomerate, and which occurs at many points in the chain, not only on the limits but in the interior of the rocky masses. Its origin is probably of this kind. The movements of the mountain mass were unequal in different parts, and on different lines. Relative as well as absolute displacements, happened, by partial crushings, and innumerable little fissures among the slightly displaced pieces of rock. These recemented, constitute a hard and solid breccia, the parts of which, unequally acted on by air and moisture, show themselves with more or less distinctness. The surfaces being often coated with oxide of iron, and the mass more or less rotten by the decay of the hornblende or felspar, or both, a great variety of appearances results. A series of specimens may be taken, at one end deserving the title of syenite, at the other of breccia or even conglomerate. But in hardly any case is the rock to be described as formed by reaggregation of pieces brought together. It is formed by cementation of the parts of a crushed mass.

On the western face of the End Hill and approaching toward its northern extremity, we trace the lower Silurian beds—conglomerates and sandstones of a gray and purple colour, near to the trap, and in one place almost into actual contact with it. There is in this case no induration and no metamorphism whatever. These beds are some hundreds of feet *lower* in the Silurian series than the shelly conglomerates already mentioned below the Worcester Beacon.



The circumstances which accompany the appearance of these rocks, especially in Cowley Park near North Malvern, are curious enough to deserve special notice. On the Bromyard road, a little beyond (N.W of) Cowley Park Farm, the appearances sketched in the subjoined diagram are seen in the cutting.



Two small bosses of syenite (s) alternate in position with two small hollows in the same rock. In these hollows are accumulations of reddened drift (r^1), amongst which pebbles of quartz are somewhat conspicuous, and generally the pebbles of all sorts are remarkably glazed on the surface, a character which is noticed in the lowest new red conglomerate at Haffield Park, and south of the Malverns. It is probably of the same age and is of very limited extent.

On the west of the syenite are purple and gray sandstones (LS^3) with some coarse or conglomeritic, and shaly parts. These beds have generally a strike to N. 20° W. and dip upwards of 80° W., but close to the trap they seem to dip under it, being in fact there, as in so many other parts of the Malvern Hills, overthrown to a reversed position. The gray sandstones are fossiliferous and yield species like those of the Obelisk beds in Eastnor Park, though they are somewhat lower in the series, and in fact are *covered* by a great thickness of purple sandstones and conglomerates, comparable to those which lie *under* the obelisk beds.

On the eastern side of the syenite, beds which belong also to this very low part of the Silurian scale appear (LS^1), but they are for a certain distance remarkably indurated, and full of fissures, and on fracture appear to deserve the title of quartzite or quartz rock. They are partly white and partly brownish. Farther off from the trap the sandstones assume a brown tint, exhibit several degrees of hardness, and contain indistinct traces of marine plants (LS^2).

Next to this, which may be called the lower Caradoc series, appear suddenly the shaly and calcareous bands to which we give the name of Woolhope Limestone (w), above this a certain breadth of calciferous shales, and these are followed unconformedly, by a fault, and the new red series (r^2), (which, however, is not seen in the road).

The metamorphic character of the sandstones on the eastern side of this trap (LS^1) can hardly be questioned: it is, however, chiefly by augmented induration that they are changed, and this is certainly known to

happen along lines of fracture and pressure where no igneous rock is visible. Have not silicated waters passing along divisional planes, effected some of the transformations which are usually ascribed to mere heat?

The rocky axis of Malvern, prolonged to the north, beneath the strata of the Martley and Abberley Hills, is visible at the surface in one spot only. This is in a field north of Berrow Hill, as described by Sir R. Murchison.* It is a very small convex mound of the red syenite, (s) about 60 yards across. In one part of this small excavation, beautiful silvery mica may be gathered in handfuls, from a rock much like the granite of the Worcester Beacon, but more disintegrated and even rotten. On the west is the old red sandstone (R), on the east blue coal shale (c) followed by new red sandstone (r), the whole presenting relations which the subjoined section represents. (None of the rocks are metamorphic.)

The elevation of this point above the sea is about 410 feet.

Beyond the Abberley Hills, to the north and also to the west of this range, several trap eminences and ridges occur, but they are not composed of "Malvern" rocks, nor do we find these peculiar mineral aggregates in any part of the districts lying southward of Malvern, though the line of the displacement with which they are locally connected at Malvern, is traceable to Tortworth, where indeed trap rocks abound, but they are of a different mineral character, and appear under different circumstances. In the districts of May Hill and Usk, no

COMPOSITION AND ORIGIN OF THE MALVERN ROCKS.

By the geologists of the last century the rocks of the Malvern hills must have been included in the so-called primitive class; later writers speak of them as comparatively modern products of heat: they are often comprehended in a single term, such as trap or syenite. But, in truth, the constitution of the Malvern chain is far less simple than such modes of designation may be thought to imply. There are in it granite, syenite, greenstone, hornblende rock, felspar rock, serpentinous rock, epidotic rock, and other nameless products of igneous action. A rock which cannot be technically distinguished from gneiss is abundant, and some varieties might receive the name of chloritic, and even micaceous schist. But the manner in which all these are associated, and some of them graduate into others, is so perplexing, and the phenomena are so continually and variously repeated, even in very limited tracts of the mountain, as to demand the utmost care in reasoning on their probable origin. The laminations are not always due to aqueous action, the veins are not always masses filling fissures, and rocks violently contrasted in colour and composition may nevertheless be parts of one and the same original unerupted lava current.

The rocks of the Malvern hills are composed principally of the minerals, quartz, felspar, mica, chlorite, hornblende and epidote; magnetic iron ore, sulphuret of iron, sulphate of barytes, carbonate of lime and carbonate of iron may be noted as of rarer occurrence in fissures, or disseminated in small proportions among certain groups of the other ingredients.

Felspar is the most abundant of all these: hornblende holds the second rank, and is succeeded by quartz and mica. Epidote, in small quantities at any one place, occurs at many points, especially in the northern parts of the range of hills.

The most frequent and abundant of all the combinations of these minerals is a mixture of felspar and hornblende, with a variable proportion of quartz: a mixture of felspar quartz and mica is less common. In veins and ramified masses we have often crystallized felspar alone, or felspar with a few included lumps of quartz, and a few scales of mica. Felspar also occurs in great masses in a fine-grained or compact state; mica appears, sometimes abundantly, alone in irregular masses and bands or seeming dykes; chlorite forms a segregated dyke and is perhaps recognisable in a disseminated state.

The felspatho-hornblendic compounds are so variable in the proportion of their constituents as to become almost purely felspathic, or almost wholly hornblendic; and so unequal in the degree of crystallization as to offer crystals expanded to a diameter of one inch across or a confused granular mixture of indistinguishable minerals.

In addition to these masses in which the crystallization of the component parts is usually the marking character, we find other combinations more or less similar, in which a rude banded appearance caused by the peculiar arrangement of the minerals offers some resemblance to structures of deposition, besides some truly laminated and schistose rocks.

Besides these, especially on the borders of the hills, are limited masses of a brecciated structure, the seeming fragments being of the nature of the rocks already named.

The following nomenclature has been found convenient and practically applicable to the designation of these extremely various rocks:—

SYENITIC GROUP.—Composed of felspar and hornblende, with a little quartz, viz:—

Red or Felspathic Syenite—in which the felspar predominates, and is of a red or reddish tint.

Mottled Syenite—in which the hornblende rather exceeds, and the felspar appears in beautiful spots and ramifications.

Green or *Hornblendic Syenite*—in which the felspar is in small quantity disseminated in almost uniform masses of hornblende, which is generally of a dark green, but sometimes of a black colour. This varies to what may be termed

Hornblendite—or masses of mere hornblende.

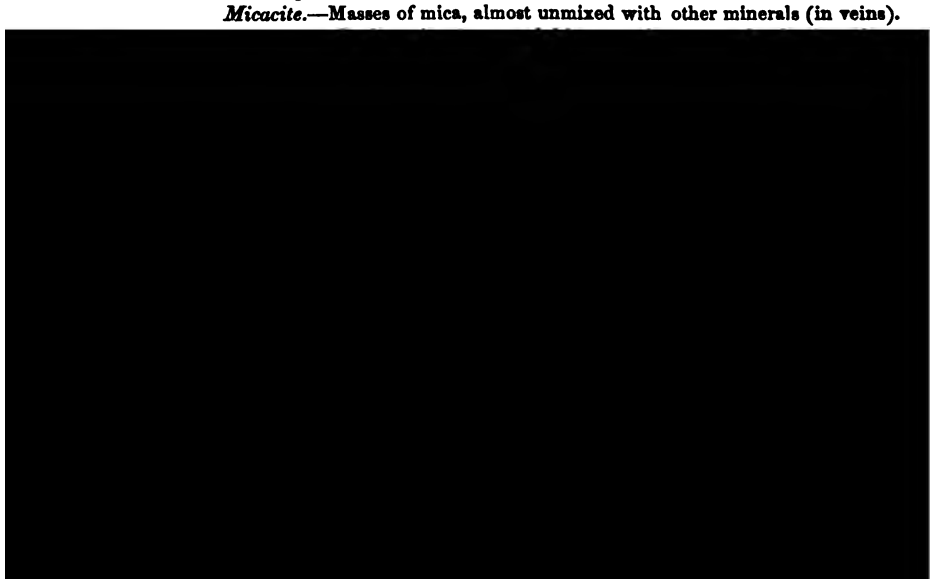
Serpentinite—a soft mixture of the above minerals.

GRANITIC GROUP.—*Granite.*—Composed of red felspar, gray quartz, and pale silvery mica.

Crystallized Felsparite or *Felstone.**—Composed almost wholly of red felspar and some quartz, with occasionally a little mica, or hornblende.

Compact Felsparite (in veins).—Uncrystallized gray or pale quartzose felspar rock.

Micacite.—Masses of mica, almost unmixed with other minerals (in veins).



the Malvern and Abberley Hills. Obscure and irregular traces of bedding may be often observed in it as in the Keys-end and Midsummer Hills, and in North Hill. It is largely exposed in quarries and road cuttings at North Malvern, above Great Malvern, along the line of the Wych Road, in the road to Wind's Point, near Walm's Wall, near Fair Oaks, about Whiteleaved Oak, and in Keys-end Hill. It may be regarded as the fundamental rock of the chain.

Mottled Syenite.—A beautiful syenite, rich in hornblende, so as to acquire from this mineral a green or elegantly mottled appearance, is developed almost coincidently or collaterally with the red syenite. Thus in the North Hill, Summer Hill, and generally in the eminences north of the Worcestershire Beacon, and on the eastern ridges of that hill, this rock catches attention, often only in loose blocks and small masses, which, by the process of weathering, become very conspicuous and attractive. The hornblende crystallizations are generally large and very distinct, of a dark green or black, while the felspar, white, greenish, or reddish, and indistinctly crystallized, sometimes envelopes, but often is immersed and ramified in, the abundant and lustrous darker mineral. As already observed, it is in the northern parts of the Malvern range and especially north of the Worcestershire Beacon that this beautiful rock appears most abundantly. It is, however, not entirely absent from any of the hills, at least in small masses. On the crest of Swinyard Hill it may be found amidst the great variety of compounds which that narrow and interesting ridge presents. When the granulation is very small the rock becomes undistinguishable from some kinds of greenstone, but there appears no particular convenience or advantage in adding that to the other terms descriptive of the Malvern rocks.

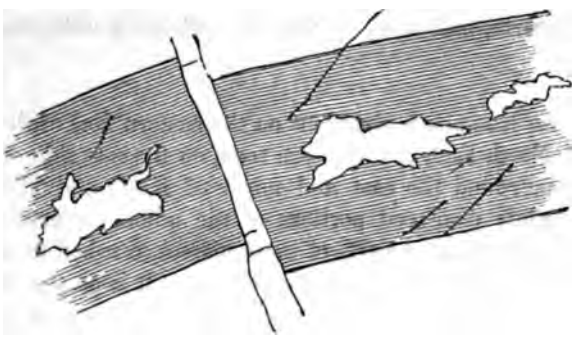
Hornblendic Syenite and *Hornblendite.*—The masses of fine-grained dark rock referrible to this title occur frequently in limited patches and in seeming dykes, on the road to the Wych, on the turnpike road above Little Malvern, on the slope of the north hill above Great Malvern, and in many other places. The crystallization of these masses is confusedly granular. But in the Herefordshire Beacon, in Swinyard Hill, and in Midsummer Hill, *especially on their western sides*, laminated rocks of dark crystallized hornblende occur, the lamination being due to the arrangement of the planes of crystallization. These are often variegated by parallel bands and crossing veins of red felspar, and specimens may be chosen which much resemble others taken from the bed of Glen Tilt. Minute cracks in this rock are sometimes filled by what seems to be light green serpentine. The rock is not at all, or very feebly attracted by the magnet.

GRANITIC GROUP.—*Granite* is much less abundant than syenite in the Malvern Hills, apparently because its micaceous element is less abundant than hornblende. In the Worcestershire Beacon varieties of rock may be collected from a very narrow area, some of which, speaking mineralogically, are syenite and others granite, just as in the crystallization of the mass the element of potash or oxide of iron was locally prevalent. In general these granitic rocks are to be regarded as local segregations, in the syenitic masses, closely allied in nature and mode of appearance to the felspathic veins which appear in almost every excavation, ramifying amidst the hornblendic masses.

Micacite.—When the mica, almost universally light-coloured (sometimes of a golden hue), is locally collected into a sort of dykes, or veins, ranging for short distances, with but little of foreign admixtures, this name appears convenient.

Crystallized Felsparite.—Nothing is more curious in these hills than the numerous and intricately ramified masses of felspar, usually reddish,

masses of quartz (the excess of that substance beyond what was



Felspar Vein, including Quartz, and crossed by a Fault.

absorbed in the trisilicated compound of felspar) appeared in the middle, and similar appearances on a greater scale in the Worcestershire Beacon. In very massive granitic rocks, whose composition is nearly uniform, the micaceous veins (felspathic or granitic) range with considerable regularity; but in syenitic rocks of less mass and less uniform composition this seldom happens.

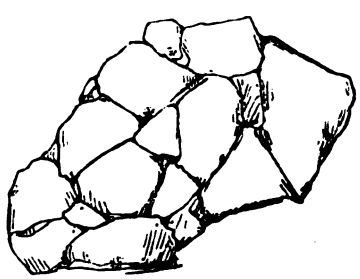
Felsparite may be termed *quartziferous*, *micaceous*, or *hornblendic*, according to the minerals which appear scattered in small quantity in it. If uncrystallized as a mass, and yet holding a few scattered pearly crystals of felspar, it may be termed compact felsparite or felstone. Really porphyritic structures are hardly to be traced in the Malvern Hills. Euritic *dykes* are absent, as well as the metallic treasures which they accompany and indicate in Cornwall and Cumberland. But compact felsparites are frequent, in the eastern parts of the Hereford Beacon, and in a greater part of the Raggedstone Hills.

Serpentine in any of its nobler forms does not occur in the Malvern Chain; but a soft rock in the Raggedstone and Herefordshire Beacon Hills appears to be of the same general character, and gradually to pass into an ill-characterized greenstone.

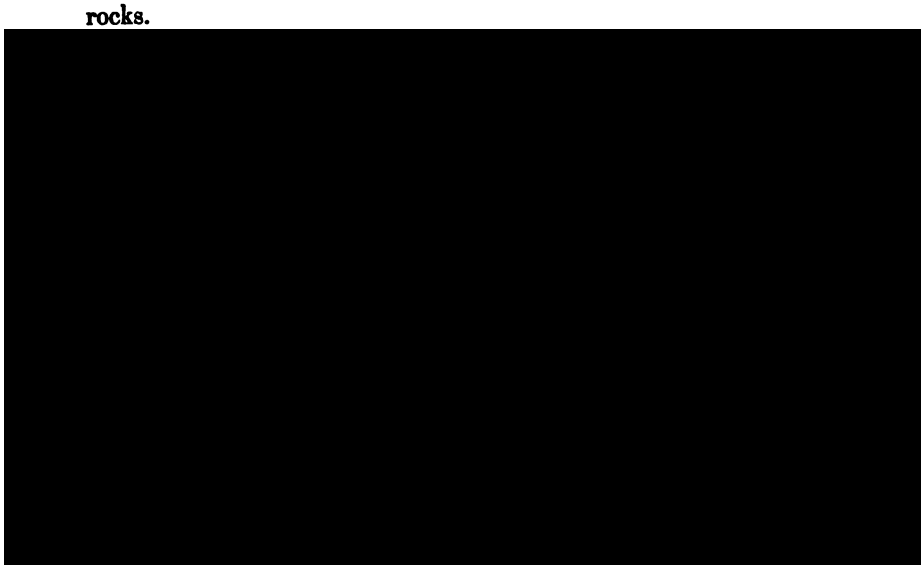
Schistose Rocks more or less approaching to the character of gneiss are more abundant in the Malvern Hills than might be expected. They occur principally in the west Raggedstone Hill, about its summit; in the northern parts of the Midsummer Hill, and in the hills south of the Wych; but there are various other more limited exhibitions of such compounds. It is remarkable that the lamination or bedding of these rocks is directly or obliquely across the ridge, but there is no great regularity or continuity in this respect. The laminæ, in some

specimens which may be collected on the path between Malvern Wells and the Wych, are very much twisted, and the whole arrangement of the felspar, quartz, and mica, is that of sufficiently well-characterized gneiss.

Brecciated Rocks are abundant on the eastern face of the Malvern Chain, as at North End, in the Wych road, on the east side of Ragged-stone Hill, and round the east and north of Key's-end Hill. They consist of slightly displaced portions of the adjoining masses, or else appear to be only crushed parts of these masses, crushed *in situ* by the force which displaced and broke the chain, as it is on the line of the great fault, and in places where much movement may be believed to have happened, that these rocks appear. The fragments, very little worn or rounded by attrition, and consisting always of the same minerals as the neighbouring rocks, have become recompacted into rather firm aggregates, with occasionally the exhibition of some crystallized substances in the few fissures left by the process.

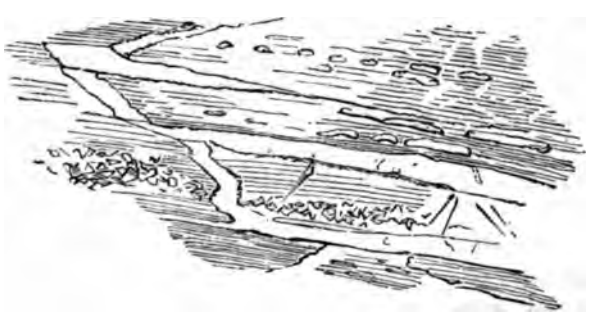


Considered in regard to their structure, these various compounds may be viewed as granular, banded, veined, schistose, and brecciated rocks.

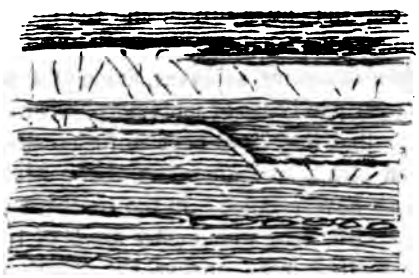


The igneous origin, the entire fusion, and the generally unrestrained crystallization of these compounds are now universally admitted. There is no instance of their occurring as dykes, among the adjacent palæozoic or mesozoic strata; no good case of metamorphosis along their borders, nor any probability that they have been in fusion since the æra of even the earliest Silurian strata on the borders of the Malverns, unless this should be thought to have occurred in the southern parts of the chain, in the Raggedstone Hill, near which *other kinds* of trap have certainly been effused in a melted state during the Silurian period. In the northern parts of the chain the anteriority of these rocks to the greater part or all of the Silurian strata appears clear.

Banded rocks, in which the same minerals exhibit a certain irregular and interrupted alternation in consequence of peculiar segregations during the process of consolidation. In these rocks felspathic bands divide a hornblendic mass, and hornblendic bands divide felspar; or grains of these minerals are more accumulated in particular places than elsewhere, so as to make more or less distinct laminar structures. The sections across these laminæ vary as under, the whole being united by frequent crossing veins or ramifications, usually composed of the felspar.



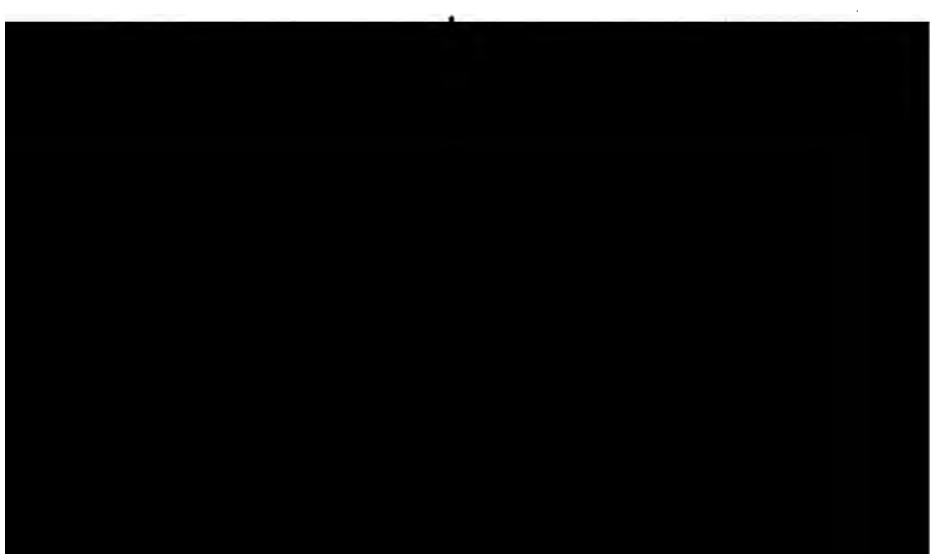
This structure accompanies most of the syenitic rocks in the Malvern Hills, being most frequent but least regular in the red syenites, and in the richly hornblendic rocks assuming, in consequence of the crystalline aggregation of the hornblende, a decided laminated character; so that bands of pure hornblende crystals, and bands of red felspar with some quartz, alternate with some regularity. In the immediate vicinity we sometimes find nearly the same proportions of felspar and hornblende in minute granular crystallization, and in connexion with the banded red syenites plenty of granular red syenite (like that of Scaleforce in Cumberland) or of largely mottled syenite, and the two varieties of structure are evidently merely the result of local crystalline arrangement, and not due to the separate agencies of water and heat.



The laminæ and banded structures may be regarded as indications of crystallization under restraint; such restraint having reference to particular planes in consequence of the *pressure* of pre-consolidated parts adjacent, or of the *flow* of heat in particular directions. Analogous phenomena happen in the mixed products of furnaces, and in volcanic aggregations, and it is in conformity with this view that we find these structures so often developed independently, though contiguously, and seldom clearly perceive a *gradual* change from one to the other, but more frequently a sudden cessation of each conterminous arrangement. The same principle applies to the vein structures which are to be noticed. These banded rocks never appear as dykes or veins in the adjacent strata, nor produce in them any remarkable metamorphosis.

To show how various may be the structures which crystallization developes in a cooling *mixed* fluid mass, such as the melted silicates of soda, lime, magnesia, iron, &c. constitute, let us admit that the situations and successive formations of crystals in such a mass depend on the state of heat (*t*), the pressure (*p*), the rate of cooling (*r*), the state of the chemical combinations (*c*), and the electrical influence of the surrounding masses (*e*).

Then against a cooling exterior solid mass (A) let a crystal (*f*) begin



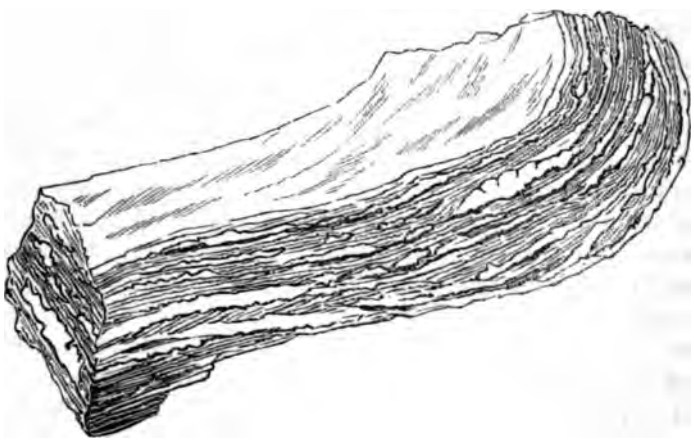
impossible to determine, *à priori*, whether it shall be of the same chemical nature as *f*, or of a different nature; whether it shall be in contact with *f*, or detached from it; symmetrically situated with reference to it, or independent of it.

Thus we may have granitic, porphyritic, laminated or veined structures, and combinations of these derived from one silicated mass, according to variations in the causes which permit and restrain crystallization in the several parts into which the mass usually divides itself. There may, however, be no such division at all apparent, but a uniformly consolidated mass, such as fine-grained greenstone, compact felspar, or serpentine. The numerous and interesting felspar veins, and the more limited quantities of granite to which they bear so direct an affinity, are all to be regarded as contemporaneous *segregations* produced in the course of the consolidation of the generally syenitic mass of the Malverns, not subsequent *injections* pressed into fissures of those rocks, by a subsequent and separate effect of heat. The extreme irregularity of these granitic and felspathic veins (as beautifully seen in the cutting of the Wych road) may be with reason ascribed to the irregular rates of cooling, the complicated direction of currents of temperature, and the changing intensities of electrical action in rocks of such varying elementary constitution. No such veins appear in any of the adjacent strata.

Besides the rocks already named, whose peculiar characters are not inexplicable by considering the circumstances of their consolidation from a state of igneous fusion, there are other seemingly stratified masses to which this view is less if at all applicable. Such in particular are the laminated micaceous rocks seen a little south of the Wych, and in the hills above, especially north-west of Malvern Wells; the laminated beds, which derive a dark colour from hornblende, seen in the road from the Wych to Great Malvern, and the laminated beds in the section along the turnpike road above Little Malvern. Perhaps geologists might think this list should be increased by adding the laminated hornblendites of the Herefordshire Beacon, Swinyard Hill, and Midsummer Hill, if not some analogous rocks in the North Hill, but though the lamination of the hornblende and its alternation with felspar in these rocks offer some difficulty, it does not appear incapable of solution by considering all the circumstances which influence the structure of rocks during the progress of cooling and crystallization.

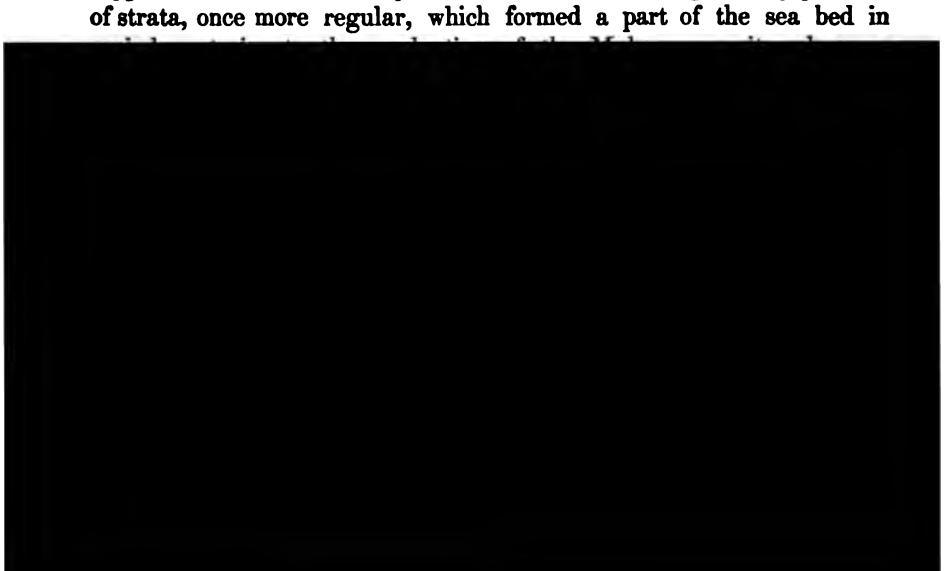
Taking, then, as examples of these structures, the bedded rocks near the Wych, which dip to the S.S.E. and S.E. (about 60°), we find a series of laminations with micaceous surfaces, approaching to parallelism, but interrupted and rendered irregular by lumpy and ramified masses of mingled felspar and quartz, constituting altogether

a rude and nodular kind of gneiss. Beds of this kind appear in ridges and hollows at intervals for a considerable distance along the hills further south, and may be examined between the Wych and Malvern Wells. These ridges cross obliquely the main chain of the hills, and are continually interrupted by and mingled with various purely pyrogenous rocks, as fine-grained syenite, with epidote veins, and the ordinary red syenitic and granitic masses.



Near the turnpike on the Wych road, a variety of dark and gray laminated beds appear, partly micaceous and partly tinted by hornblende. Their structure contrasts much with the massive hornblendic traps with granitic segregations, which abound in the line of this road.

Appearances such as are described, are frequently seen less completely in other parts of the chain, and they seem consistent with the supposition that these rudely structured rocks are fragmentary portions of strata, once more regular, which formed a part of the sea bed in



From what has been said, it appears that a great variety of rocky aggregates in the Malvern Hills is clearly of igneous origin: it is equally clear that many of their complicated mineral and structural appearances are due to the local segregation of particular minerals from one fused mass of silicated earths.

Enclosed in this mass, are rocks whose structures are not due to segregation of parts from the same mixed fluid compound, nor to metamorphosis of parts of the immediately adjacent strata. These gneissic beds, inextricably entangled as they are in the syenitic range, have no real conformity with it in direction, but strike obliquely or directly across it, and appear to be parts of stratified masses more ancient than it, rather involved in and penetrated by, than really forming an integrant member of the Plutonic series.

The upheaval of this mingled mass from a considerable depth has impressed upon it some additional characters. This upheaval appears to have been violent. Hence the abrupt truncation of the eastern face against the new red sandstone plain, the striation and furrowing of that face, the brecciated structures along it, and the numerous lesser faults and cracks which traverse and split the rocks in points adjacent to the surface of greatest displacement. The vertical amount of this displacement on the eastern boundary of the Malvern chain cannot be less than some thousands of feet; and to the various slidings of the broken masses of rock on one another we may perhaps ascribe in part the short pseudo-stratifications of the syenite, the glazing of many surfaces with abraded hornblende, and possibly some of the rude laminations which appear in the hills.

Upon the whole, there is no evidence in the nature and structure of the Malvern rocks to justify the notion which the linear character of the hills suggests, that they are to be regarded as compounds crystallized by cooling from a mass *erupted in fusion along a particular fissure.* On the contrary, it is concluded that they are a mass of varied and mingled rocks, in most of which an igneous origin or igneous metamorphosis can be detected, that they were solidified at some considerable depth in the sea, and thence raised up along a great line of fracture *passing through them* on the eastern side. With them were raised vast piles of strata (palæozoic) which had been deposited above and around them, and, at a later time, other strata (mesozoic) were laid against their broken edges. To the description of these strata and their relation to the Malvern chain as a general support, we now proceed, with the aid of sections, diagrams, and a coloured geological map.

STRATIFIED ROCKS.

GNEISS SERIES.

The lowest stratified rocks visible in the tract of the Malvern Hills are certainly those gneiss-like beds already noticed, which are irregularly and inextricably mixed with the true traps, and have enough of the characteristic appearance of altered strata to countenance the supposition that such change is a part of their history,—a history certainly anterior to that of a great part if not the whole of the Silurian deposits which are seen on the borders of the Malvern syenite.

The localities most worthy of examination with reference to rocks of this ambiguous nature have been already indicated while speaking of the different hills, but it may be as well to collect them in one point of view.

In the East Raggedstone, ridges of laminated felspathic rocks, and schistose rocks with mica, divide the ordinary traps in lines from N.E. to S.W., and from E. to W.

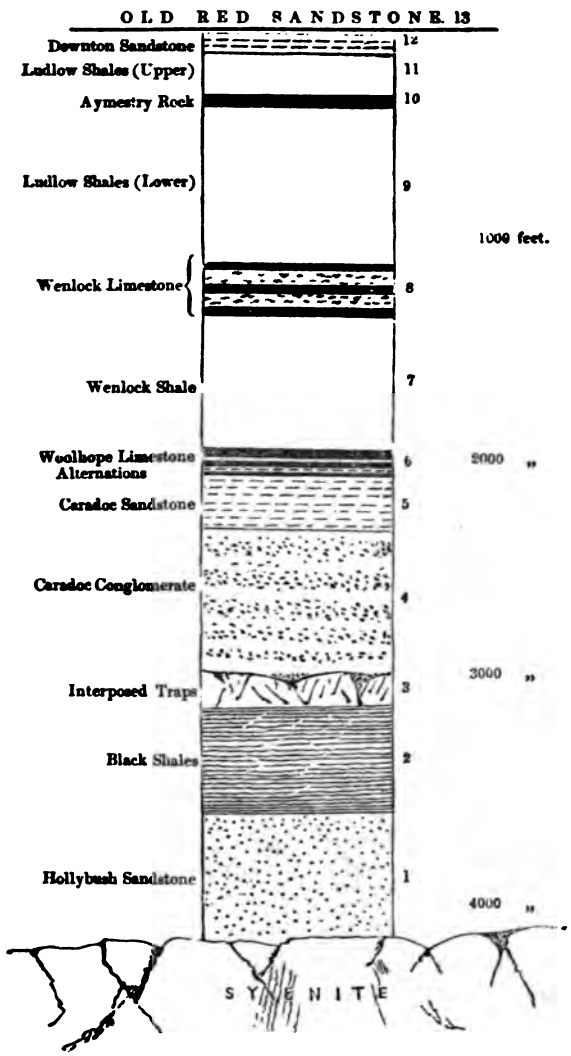
Near the western summit of the Midsummer Hill, gneissic rocks ranging N.W. or W., and dipping steeply southward or northward, appear abundantly.

The felspathic ridges which cross the eastern buttresses of the Hereford Beacon Hill, in lines ranging N.E. and S.W., appear to be of the same nature and origin as the similar bands in the East Raggedstone.

Gneissic laminations may be traced at many points north of the Hereford Beacon, and the footpath from Malvern Wells to the Wych is crossed by many examples of distinctly micaceous gneiss with flexuous laminæ. This rock is even abundant in the hills as far north as the

PALÆOZOIC STRATA OF THE MALVERN DISTRICT.

Vertical Section of the Silurian Strata in the Malvern Hills.



1. HOLLYBUSH SANDSTONE.

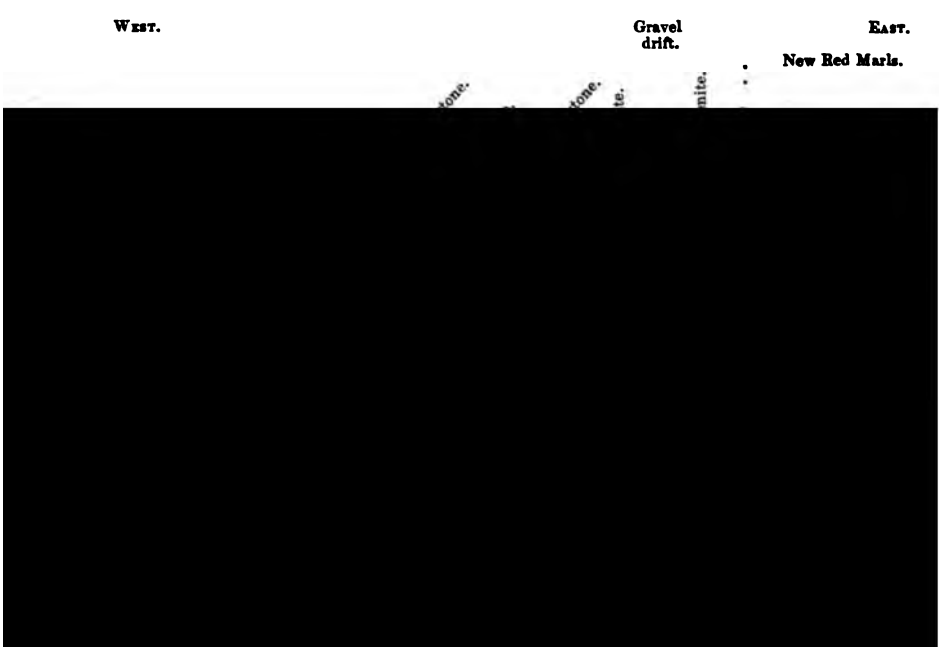
Greenish gray or brown sandstone, with fucoidal impressions (thickness 600 feet).

The lowest strata not involved in the trappean mass of the Malverns are those which lie on the western side of the chain, rising to

high ground, and appearing to form part of the Malvern range on the sides of the valley through which the London road passes between Midsummer Hill and Raggedstone Hill. These strata are sandstones of a dry harsh feel, often of a greenish colour, and sometimes of a rather trappean aspect: they have yielded no distinct traces of organic remains except fucoidal impressions.

In the south-western parts of Raggedstone Hill these beds are seen in apposition to the trap, and the appearances which they there present are noticed, p. 27. On the western face of the same hill, they appear with a nearly regular strike to the N.N.W., and dip to the westward from 60° to 90°. Some of the beds here are more laminated and more micaceous than usual. At the north end of this hill, hard conglomeritic grits (containing felspar and quartz in grains, and small fragments derived from the neighbouring hills) appear with the greenish sandstones, and wrap round the hill, and descend toward the valley on the north. Through this valley (Hollybush Valley) the London road passes, and the sections along it, and along another road a little to the north, shew some interesting facts.

The summit of this valley exposes the syenite of the Malvern chain; on the east are the new red marls, with keuper sandstones (near the middle of the mesozoic strata); and on the west the greenish sandstones now under consideration, which form the lowest member of the palæozoic strata of the Malverns. The red sandstones and marls lie nearly level, the greenish sandstones are highly inclined, and divided by a felspathic dyke, and perhaps by an interposed felspathic mass. The general character of the section may be thus imitated in type.



trap succeeds, apparently interposed among the beds of sandstone, and of considerable thickness. Then follow gray and greenish sandstones in thin hard beds near the trap, in thicker and softer beds farther from it, so as to allow of a larger quarry of good stone, on a strike to the N.N.W. and with a dip of only 30° to the west. The bedding in this quarry is very irregular: the stone is of a dry harsh feel, and of a greenish tint previous to exposure. It contains large apparently fucoidal impressions, but no sure marks of any other organization were found.

The road a little to the north of this deserves a visit on account of the great quarry there, which shows greenish sandstones (soft and with hardly any decided beds) on the east as well as west of a distinct felspathic dyke, in which the glistening of minute felspar crystals, and rarely a scale of crystallized mica, can be detected. The colour of the felspathic base is variable, and the observer may on a first view be deceived as to the extent and thickness of this dyke; for the stratification of the sandstone is very obscure, and some parts of it require careful attention to be distinguished from the trap. This dyke dips to the east; the felspathic mass on the London road seems to be interposed in beds which dip to the west; yet they may belong to one and the same igneous mass which, erupted amidst the sandstones, may in one part cross them, and in another for a short distance be irregularly interposed. West of the quarry which has been thus noticed, the greenish sandstones prevail, highly inclined, and run along the west side of Midsummer Hill, being succeeded by the black shales of considerable thickness, which form the next group of strata.

It may be remarked that this series of sandstones is devoid of any thing like regular bands of shale, lines of calcareous concretions, or layers of fossils, and in all these respects differs from the Caradoc sandstones of later date.

Its appearance suggests the notion of its having undergone some unusual heating, but except at the south-western end of the Raggedstone Hill, in contact with the syenite, and by the side of the dyke near the London road, its character as a deposited sandstone is scarcely altered. The phenomena which accompany its contact with the trap of the Raggedstone have been already described, p. 27. The maximum thickness of these sandstones has been estimated at about 600 feet; they appear in a very limited area, and may perhaps be of small extent, but this cannot be proved by observation.

Organic remains. These consist only of impressions of marine plants, from which all trace of carbonaceous substance has been removed; a circumstance very generally observed in relation to fucoidal vegetation. Possibly further research and better fortune may

detect other remains in the laminated parts of these beds, but my repeated examinations have been fruitless. It is necessary to caution those who may follow me against an easy mistake. There are beds of true Caradoc sandstone (No. 6) with fossils in tolerable plenty near Fowlet Farm, thrown down by some obscure but powerful displacement, or deposited unconformably, and traces of the same kind occur between the Obelisk and Midsummer Hill, from the same or a similar cause. These localities must be excepted from the catalogue.

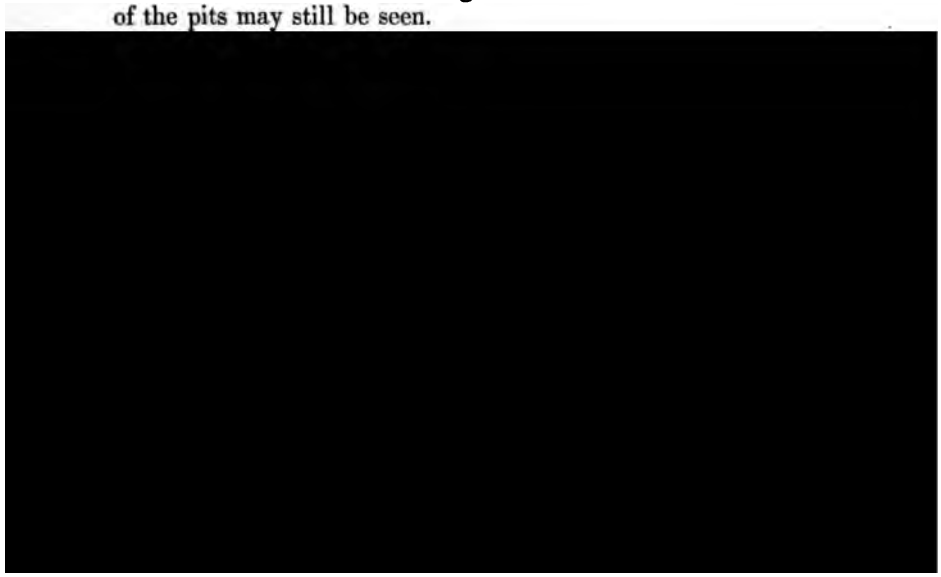
2. BLACK SHALE.

Thinly laminated uniform carbonaceous shale, with trilobites (thickness 500 feet).

The superposition of the black shale on the greenish sandstones is certain; and is to be inferred from the relative position which it occupies on the map, and the general conformity of dips, supported by a few clear and positive examples in vertical sections. It appears on the west side of the greenish sandstone along the side of the Raggedstone Hill, and is seen in similar relation on the London road, and on the south-west slope of the Midsummer Hill, always in low ground. In these cases the subjacent sandstone appears generally to dip westward. This shale occupies a considerable surface on the north-west side of Keys-end Hill, and west of Raggedstone and Midsummer Hills, almost filling a large triangular hollow, which is overlooked by the escarpment of the fossiliferous Caradoc sandstone.

In Coalhill it alternates with the green sandstone, and in this and other localities is in contact with trap, and is bleached by its influence. In the black state it contains carbon, but no potash.

The dark colour of this shale must be the excuse for several vain trials for coal, made in the low ground about Whiteleaved Oak. Some of the pits may still be seen.



ORGANIC REMAINS.

As before observed, these are exclusively trilobites, no fucoids, no zoophyta, no brachiopoda, having yet been detected in the only locality yet found to yield fossils, viz., between Fowlet Farm and Whiteleaved Oak. They are all small, and for the most part minute. As the most ancient specimens of the marine fauna of Malvern, they have been scrutinized with as much care as their imperfect state allows; and the following short list includes all that is yet determined about them. Magnified outlines are subjoined to illustrate some points esteemed worthy of notice:—

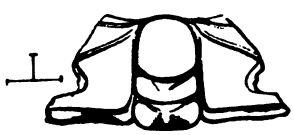


Fig. 1.

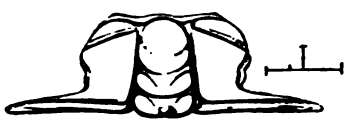


Fig. 2.

Figs. 1, 2. Olenus bisulcatus.—n. s.

Fig. 3.

Olenus spinulosus?

Fig. 4.

Fig. 5.

Fig. 6.

Figs. 4, 5, 6. Olenus humilis.—n. s.

3. INTERPOSED TRAP ROCKS.

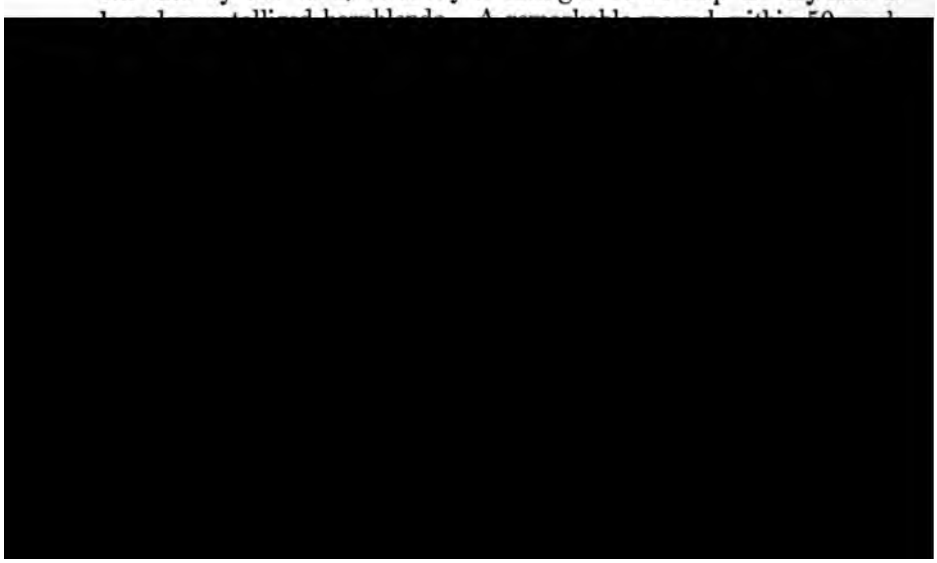
(Thickness variable, 0 to 50 feet.)

This appears the proper place to describe a series of trap rocks which, by some accident, Mr. Murchison has omitted in his survey of the Malvern district. They are particularly interesting, as connected

with phenomena quite different from those which appear along the great chain of the Malverns, being, in fact, porphyritic and greenstone masses, which, erupted from below, have flowed in limited streams over the surface of the black shales. In consequence of this circumstance, the country lying immediately on the west of the southern part of the Malvern Hills exhibits more than twelve apparently detached trappean masses, usually forming little bosses, and steep, but low cliffs, in a sort of crescent along the western boundary of the black shales, from Keysend Hill, by Fowlet Farm, and above Bransill Castle, to beneath the Obelisk in Eastnor Park. The map shows the situation of these little masses of trap; and the vertical and sea-level sections, among the published works of the Survey, will explain the interposition of this trap among the strata.

Regarded mineralogically, this trap differs from the syenitic masses of the Malvern chain. In the great chain hardly any true porphyry, genuine greenstone, or amygdaloid, can be detected. Among these traps, on the contrary, greenstone abounds, without any true syenite, and porphyritic and amygdaloidal structures occur. Two or three of the little inequalities which they occasion in the surface, are like miniature volcanic domes, owing, no doubt, to the atmospheric waste which has frequently excavated the felspathic rock to a resemblance of cellular lava. In other cases, the decomposing greenstone shows a few rude prisms and many spheroidal masses.

The following points deserve to be visited in the vicinity of Rowick Farm and Fowlet Farm. The footpath from Whiteleaved Oak to Fowlet Farm, shows the shales in places black and (to careful eyes) fossiliferous; in places the shales are bleached and indurated by contact with trap. Round Fowlet Farm are several remarkable trap mounds, one of them 120 yards S.S.E. of Rowick Farm, another E. of that farm, cut into by the road, close by a cottage. This trap is very full of



grove. It appears, then, that these bosses of trap lie on or in the upper part of the black shales, for the most part; and, as the section in the London road shows felspathic traps of the same general character, dividing in broad dykes the green, volcanic sandstone, we may safely admit eruptions of such trap, and some local displacements of strata after the deposition of the black shales. Neither dykes nor bosses of trap occur in any of the strata above those shales.

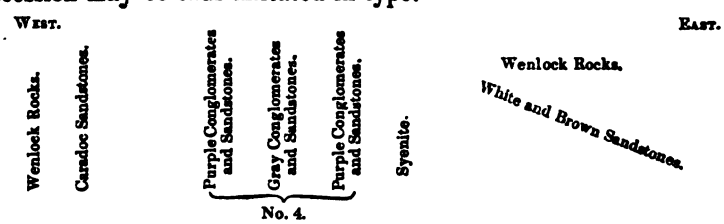
4. CARADOC CONGLOMERATE AND PURPLE SANDSTONE.

(Thickness 600 feet.)

Bounding the traps and black shales on the western side, appears a very different group. On Howler's Heath, east of Hillend, west of Rowick, east of Wainstreet, above Bransill Castle, beneath Eastnor Obelisk, and at the entrance of the valley between Midsummer Hill and Swinyard Hill, conglomerates and sandstones, more or less of a purple hue, and alternating with purple or gray shales, show themselves in considerable masses, on a line of elevated and prominent escarpment. The thick, soft, purplish, and gray and brown sandstones under the Obelisk in Eastnor Park, are a good example of part of this group, which does not much appear from this point northward till we reach the western slope of the Worcestershire Beacon. Here its renewal is heralded by the purple building stone, dug for the new church, beyond which many points along the rises of the road which proceeds to the north end of the Malvern range show purplish and gray conglomerates and sandstones of similar tints, slightly or not at all fossiliferous. The soil is tinged purple along the further course of these rocks by the End

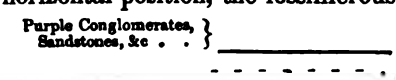
Hill, across the Bromyard Road, through Cowley Park, and up the eastern side of Rough-hill Wood, where some of its vertical felspatho-quartzose beds resemble those of Howler's Heath. Its thickness is considerable, amounting to 500 or 600 feet, in the woody borders of Howler's Heath, 300 or 400 feet below the Obelisk, and upwards of 600 feet in the country west of the End Hill. It is richly fossiliferous in the Obelisk Hill, but only along certain bands and in particular lines, which are usually marked by the cavities from which the shells and corals have been dissolved away, and in a similar manner it yields many fossils in Cowley Park. This group of sandstones is rather remarkably deficient of mica.

The series of these beds appears most complete in the northern part of the Malvern district, that is to say, in a narrow tract between Dowlas New Church and Rough-hill Wood, which adjoins the syenites of the North Hill, and of Cowley Park on their western side. The succession may be thus imitated in type.



The reader may also consult the diagram on p. 37.

The part here entitled "gray conglomerate and sandstones," yields fossils, and in very considerable abundance. The beds dip 70° or 80° W., and in places are vertical; near the trap they dip E. Replaced in their horizontal position, the fossiliferous series would appear thus.



These beds appear, from their organic contents, to be certainly comparable to the fossiliferous gray sandstones which break out below the Obelisk in Eastnor Park. The fossils are remarkably similar, and no other group of strata in this district yields the same. There is probably between these beds and the trap a greater thickness of the purple series under the Obelisk, than between them and the syenite in Cowley Park. On the other hand, there is in the ground west of the North Hill a greater thickness of the purple beds which lie over the gray fossiliferous sandstones, and by adding these parts together, it appears that the extreme thickness of these purple and gray beds, supposing all the parts existent together, may be about 700 feet.

The manner of their coming into contact with the Malvern syenites, is of great theoretical importance, and may be well understood with a diagram such as that on p. 60, which represents a section through the Malvern Hills parallel to the plane of the horizon. Minute details are suppressed for the sake of the general effect; but the older strata, already described, and those more recent beds which lie over the conglomerates, and make up the lower Silurian series, are represented in the drawing.

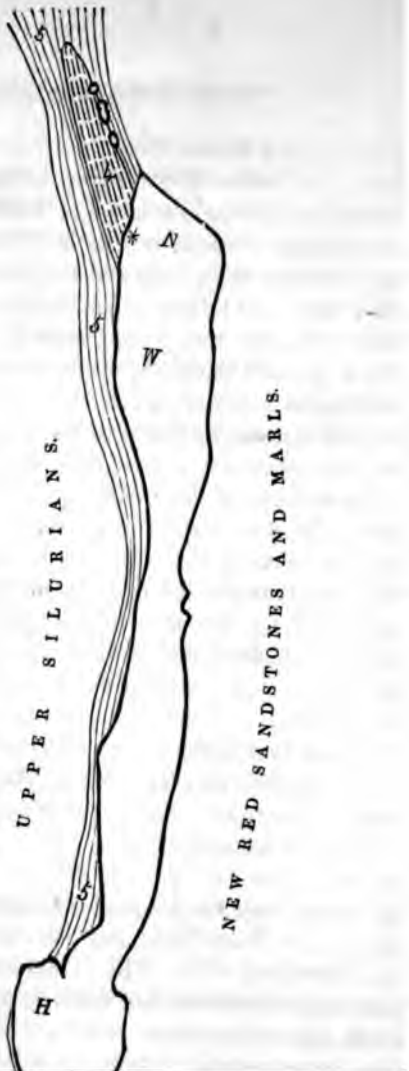
From this it appears, that while the lowest of the Silurian strata (No. 1, 2), with their associated traps (No. 3), are seen only in a sort of crescent, on the western side of the southern part of the Malvern chain, the conglomeritic series (No. 4) appears both there and at the north end. None of these beds are strictly conformable to the Malvern syenites at any point; and the conglomeritic series abuts against the trap distinctly west of the North Hill, and less distinctly so west of Midsummer Hill and Keys-end Hill. The northern contact is, fortunately, traceable, both against the detached traps in Cowley Park, and at a point farther south, against the great syenitic range. (This point is marked on the map by an asterisk. It is close behind a solitary house.) In these situations the beds are nearly vertical, or overthrown to a resupinate position dipping east, as indeed happens almost uniformly along the range as far south as Midsummer Hill. Beyond this point to the south, no case of overthrown beds is to be seen near the syenite. There is no metamorphism in the purple conglomerates where they adjoin the trap. The small fragments and grains of felspar and quartz which occur in those beds appear to be such as might be derived from disintegrated parts of the syenites adjoining; and such is probably their origin.

The organic remains collected from this group of strata, below Eastnor Obelisk, and in Cowley Park, are principally the following, which, with those already noticed in the black shales, constitute the lowest and earliest of the forms of animal life in the Malvern districts.

REFERENCE TO THE STRATA.

5 Caradoc Sandstone.
4 „ Conglomerate.
3 Interposed Traps.
2 Black Shale.
1 Hollybush Sandstone.

The hills and bosses of Trap are strongly outlined.



POLYPIARIA .	A minute favosites.
BRACHIOPODA .	Lingula attenuata.*
	Orthis bilobata.
	—— canalis.
	Atrypa orbicularis.
	Terebratula furcata.
	———— decemplicata.*
MESOMYONA .	Avicula orbicularis.*
	——— obliqua.
PLAGIMYONA .	Arca Eastnori.*
	Nucula, several new species.
GASTEROPODA .	Turritella cancellata.
	Littorina striatella.*
	Turbo Pryceæ.
HETEROPODA .	Bellerophon acutus.
	———— trilobatus.
CEPHALOPODA .	Orthoceras conicum ?
	———— approximatum.
ANNELIDA . .	Cornulites serpularius.
	Tentaculites annulatus.

Those marked with an asterisk (*) occur frequently.

5. CARADOC SANDSTONE.

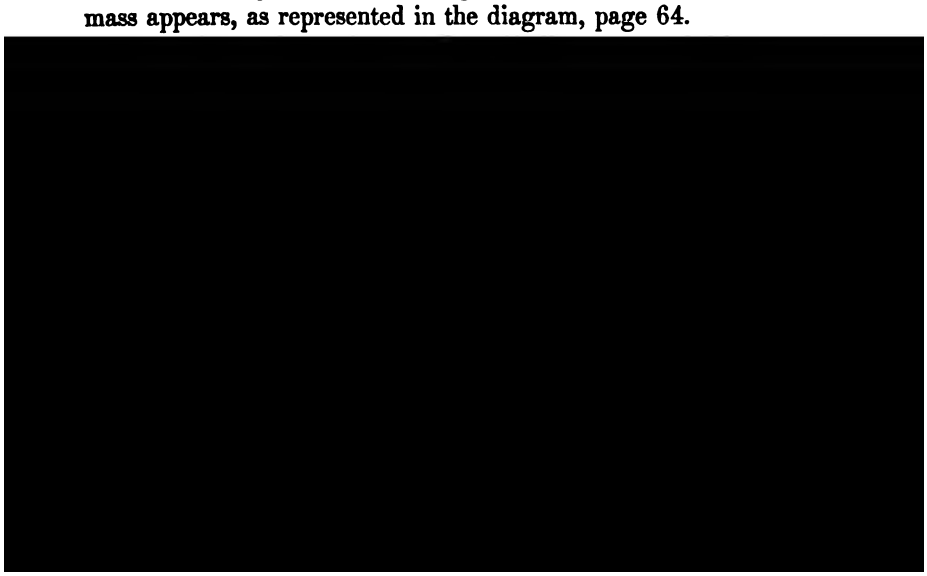
5. Gray (and at the bottom purple) laminated sandstones and shales (thickness 500 feet).

These beds of hard gray sandstone, often marked on the surface by elevated vermicular markings, or impressed by marine plants, alternate with similarly coloured clays or shales, and make altogether a great thickness of argillo-arenaceous strata, lying next to the purple sandstones last described wherever they are distinctly seen. The shaly parts of the group occupy a greater proportionate thickness in the upper part, while in the lower part the sandstones predominate. Organic remains (crinoidea, shells, and crustacea) are most frequent in the lower parts of the series. These lie not so much on the surfaces of the sandstones as in their mass, or slightly removed from the surface, so as to be disclosed by splitting the stones. Though the beds are thin, from half an inch to three or four inches, these shelly layers are often quite distinct through the stone, and there may be more than one layer in such a flagstone. Sometimes the shells are confusedly buried in the stone. They scarcely appear at all in the alternating shales. The layers are more or less continuous; but the shells, and corals, and crinoids appear to have been drifted, as happens on sandy shores at this day. These laminated sandstones are

sometimes hardly at all micaceous. On the fracture they show sometimes that greenish tinge which belongs so constantly to the older sandstones of Hollybush; but they are generally gray or whitish. In one situation, viz., extensively on the south slope of Howler's Heath, where they adjoin the new red sandstone, both the sandstones and shales are reddened to a great and delusive degree, for they might easily be mistaken for grits and shales of the old red sandstone, but for the rarity of mica and the presence of peculiar organic remains.

The range of this series of strata in the Malvern district is very easily traced from Howler's Heath, by Hill-end and Wain Street, at all of which places it may be seen in quarries, road-cuttings, or drains, dipping away from the Malvern Hills, lying upon the conglomeritic series, and covered by the Woolhope limestones next to be described. From Wain Street the sandstones may be traced through Eastnor Park, by the keeper's lodge, and across Stump's Wood, and through a part of New's Wood, in a curve returning toward Gullet Wood and the syenitic hills. (See the coloured map and the diagram on p. 60.) From this point northward, under the westward slopes of Swinyard Hill and the Herefordshire Beacon, it scarcely appears at all between the Woolhope limestone and the trap. (A singular occurrence of loose, fossiliferous Caradoc sandstones, high up the Beacon Hill, was met with.) On *the east side* of Swinyard Hill a considerable outlier of the fossiliferous sandstones was discovered, and traced from the Silurian pass, at intervals, to near the Fair Oaks Farm.

On the north side of the Herefordshire Beacon, it reappears in contact with the trap, and runs in a narrow continuous tract, by Wind's Point (where a small fossiliferous outlier occurs on the hill slope, east of the Hereford Beacon hill), Brand's Lodge, Hawket Copse, Stonesway, and west of the Wych, in the cutting of which pass a curiously enclosed mass appears, as represented in the diagram, page 64.



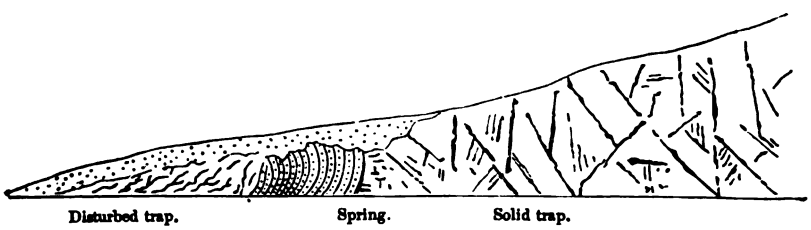
with the violent flexures and steep dips to which the same beds are subject, in the close vicinity of the Malvern Hills.

The breadth of these beds is somewhat less than half a mile, having limestones on each side. Farther north, this breadth augments, and in the middle we see again coarse conglomeritic beds like those of Rough Hill, and find them somewhat fossiliferous on the high central ridge of Birchwood and Storridge, which is crowned by the little clump, called the Beck. Here the breadth is about three quarters of a mile, but it is gradually diminished as we proceed to the north, by the action of the great downthrow fault, which, running N. N. W. from the Malvern Hills to Knightsford Bridge, brings the new red sandstones against the different members of the Silurian series in succession. From the Norest Farm by Coppice End and Birchen Hall, to the Leigh Brook, at Bridges Stone, the new red and the Caradoc sandstones are in juxtaposition (the contact being seldom visible); hence to near the cottage in Lord's Wood, the Caradoc is narrowed and complicated by the over extension of the upper Silurians, from the west and from the east, and only its upper parts are to be seen. The whole Silurian series is here depressed below red marls, sandstones, and conglomerates, which fill the vale of the Teme, and thus quits the Malvern district, after a range of 14 miles. In the course of these 14 miles many instructive sections occur which show separately the parts of this Caradoc series; there is not one where the whole can be seen uninterruptedly complete; but by attending to them all, the student will find the means of satisfying his inquiries.

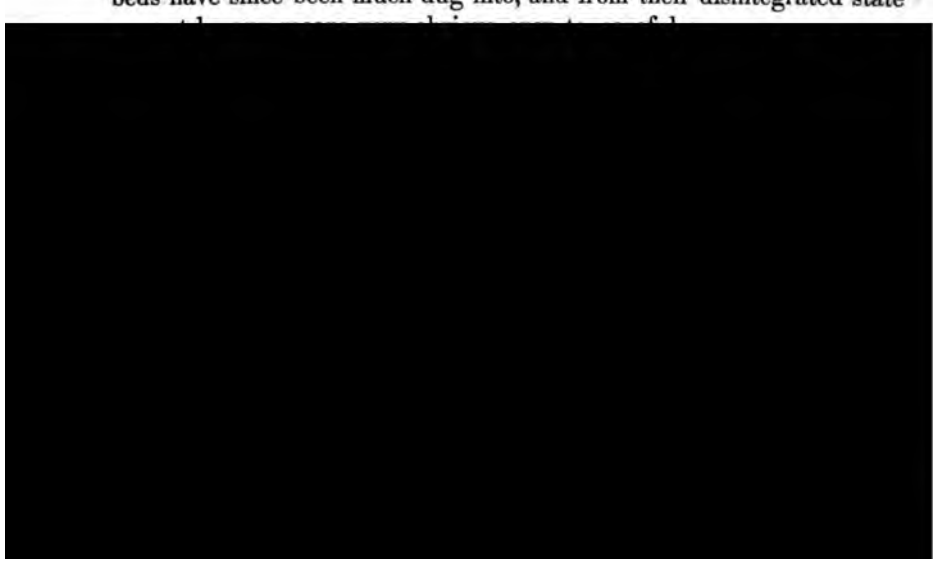
Commencing at the south end, on Howler's Heath, he may examine the conglomeritic beds (No. 4), including small fragments and grains of the syenites, and a few remarkable fossils. (*Lingula crumena*, a new species occurs here.) Then, following the road which leads southward, he may pass in succession a considerable part of the laminated sandstones and shales of the upper Caradoc, now under consideration, and observe them to be tinged very red with peroxide of iron, *on all the surfaces, from the anciently overlying but now removed red sandstone strata.* Orthides and Leptænidæ occur in these beds, which, dipping to the southward, are covered unconformably by the new red conglomerates, and do not show the uppermost parts of the series on this line of section.

Proceeding northward, the next good section is made by the Ledbury and London road, at Wain Street, where the thin-bedded Caradoc sandstone has been cut through, in a bank now smoothed by time, but still exposing some fossiliferous beds (dipping to the west), between the purple sandstones below and the Woolhope limestone above. Again, in Stump's Wood a similar series may be traced, by taking a course up

to the obelisk, where the lower series (No. 4) is found richly fossiliferous. The narrow pass between Swinyard Hill and the Herefordshire Beacon should be examined, on account of the unaltered state of the upper beds of the Caradoc, which with their thin limestones and shales, rest upon the granitic trap, covering it as with a saddle, and yield *Favosites multipora*, and other corals. The next section worthy of examination is at some distance northward, viz., in the road leading from Brand's Lodge, toward Evendine Street (the beds dipping to the east 50°), and a more complete one in the road which leads from Winning's Farm to the Wych. Taking either the old or the new road up to the Wych, we cross from the Wenlock shale over the poorly developed Woolhope limestone and the thin-bedded Caradoc sandstone to the syenite of the Wych. In the cutting of the Wych itself, on the western side of the little well, there is the remarkable pass of thin-bedded and decomposed Caradoc sandstone represented in the diagram annexed. I had the



pleasure to conduct to this patch of sandstones, enclosed between masses of trap but unaltered, Mr. Murchison, Count Keyserling, and Professor Sedgwick. Sir H. De la Beche has also inspected it, and Mr. Horner has recently added this interesting occurrence to his other pleasant memories of the Malvern Hills. It is necessary thus to authenticate the fact; for as it was revealed by the accidental cutting of the Wych, and the beds have since been much dug into, and from their disintegrated state



By turning to the west, and descending the road towards Brockhill, the collector may add to this list *Fucoids, Pentamerus lævis, Leptæna tenuistriata*, and *Encrinurus punctatus*.

The natural section under the Worcester Beacon, not only adds much to what those already mentioned have exhibited, and gives on the whole a more complete general view, but it discloses an unexpected and most important relation between the syenite and the Caradoc beds, which influences all our conclusions touching the manner of deposition of the one, and the time of fusion of the other. It will be seen, on inspecting the map (or diagram, p. 60), that the space occupied by the Caradoc sandstone, in its range northward from the Hereford Beacon, grows continually wider; and as the beds are nearly vertical, or dip to the east, it is obvious that lower and lower beds of this group of strata come up continually, and thus their apparent thickness is continually on the increase. On arriving at the parallel of the little stream which descends on the north-west side of the Worcester Beacon, both the uppermost and the lowermost beds of the Caradoc sandstones are exposed, and both under interesting circumstances.

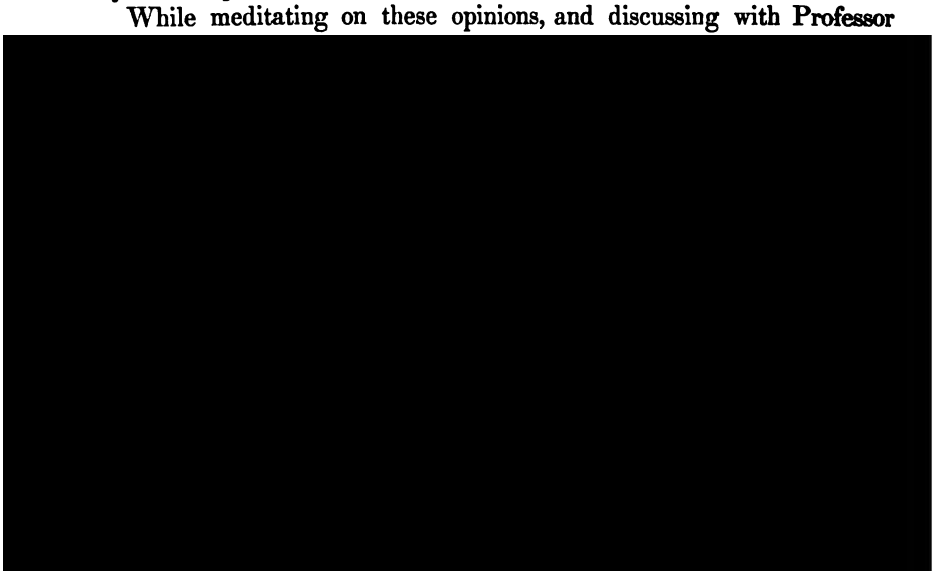
The uppermost beds alternate distinctly with the lowest limestone bands of the Woolhope series, and thus show a peculiar, but very unequivocal gradation, or alternation from the lower to the upper Silurian series. To this we shall recur when speaking of the Woolhope limestones (No. 6.) The middle part of the sandstone series is not well exhibited on account of the nature of the surface; but nearly at the bottom of the series, on the south side of the little rivulet, and adhering to the syenitic slope, with a reversed dip to the east (60°), a group of purplish and gray sandstones is quarried for walling, and there exhibits, in planes parallel to the stratification, a great abundance of organic remains. The following are the principal species, the asterisk indicating abundance:—

Fucoidal impressions.	
Trails of marine animals.	
Polypiaria .	Turbinolopsis bina.*
	Favosites alveolaris.
Crinoidea .	A small circular column.
Brachiopoda .	Leptæna tenuistriata.*
	——— complanata.
	Atrypa lens.*
	——— globosa.
	——— hemispherica.
	——— undata.
	Terebratula furcata.

BRACHIOPODA .	Terebratula decemplicata.
	Orthis testudinaria.*
	—— canalis.
	—— flabellulum (ribs divided).
	—— pecten.
	—— virgata.
	Spirifera radiata.
GASTEROPODA .	Loxonema sinuosa.
	Euomphalus corndensis.
HETEROPODA .	Bellerophon acutus.
	———— trilobatus.
CRUSTACEA .	Encrinurus punctatus.
	Trinucleus Caractaci.
	Asaphus caudatus.
ANNELIDA .	Tentaculites scalaris.*
	———— new species.
	Cornulites serpularius.*

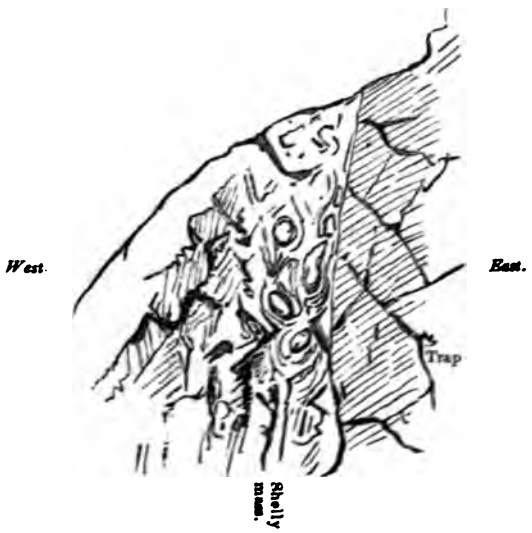
The Caradoc sandstones, wherever they have been traced to a very near contact with syenites, having appeared unaltered, and the more ancient conglomerates being observed to contain *fragments* of these syenites,—while in the midst of the Malvern Hills, stratified rocks in a metamorphic state are mixed with the traps,—it appeared *probable* that the Malvern Ridge had not been erupted in a liquid state through all the Silurian strata, but that some parts of it at least were solidified in some earlier period, though amongst the lowest of those strata local and limited eruptions of a *different sort of trap* (see p. 55) had occurred, and produced the usual effects of heat. This inference was confirmed by an unexpected discovery.

While meditating on these opinions, and discussing with Professor



shells, and pebbles, and fragments of the syenitic, felspatho-quartzose, and other rock masses of the Malvern Hills.

The next thing to determine was the position of this conglomerate in relation to the ridge of syenitic rocks amongst the detritus of which its fragments lay. This was difficult. The abundance of detritus on all the slopes is so great as to conceal for the most part the junction of the stratified and unstratified rocks. The loose shelly pieces we found abundantly for fully one third of a mile along the mountain side, and at length the conglomerate rock itself was plainly seen adhering to the extreme western nearly vertical face of the trap mass, west of the Worcestershire Beacon, in a situation laid open by a large excavation close to the road, and north of the little stream.



These facts ascertained, I waited for the arrival of Sir H. T. De la Beche at Malvern, to have the shelly bed thoroughly explored, and its contact with the trap rocks carefully traced. We found the surface of the trap nearly vertical, but undulating and irregular, and its strike nearly north and south; the rock is here hornblendic, dark green or purplish in colour, and, as usual in all these hills, it is within short distances mixed and variegated with more felspathic portions, felspatho-quartzose veins, &c. Closely adhering to it was usually a softish laminated clay; bedded in the clay, or touching the trap rock, were multitudes of rolled pebbles and angular chips and fragments of stone, accumulated in an irregular bed above a foot or only a few inches in thickness against the trap. In the intervals of these pebbles were partial admixtures of argillaceous shale, abundance of shells, and smaller chips and fragments of stone, more or less stained brown, in the same

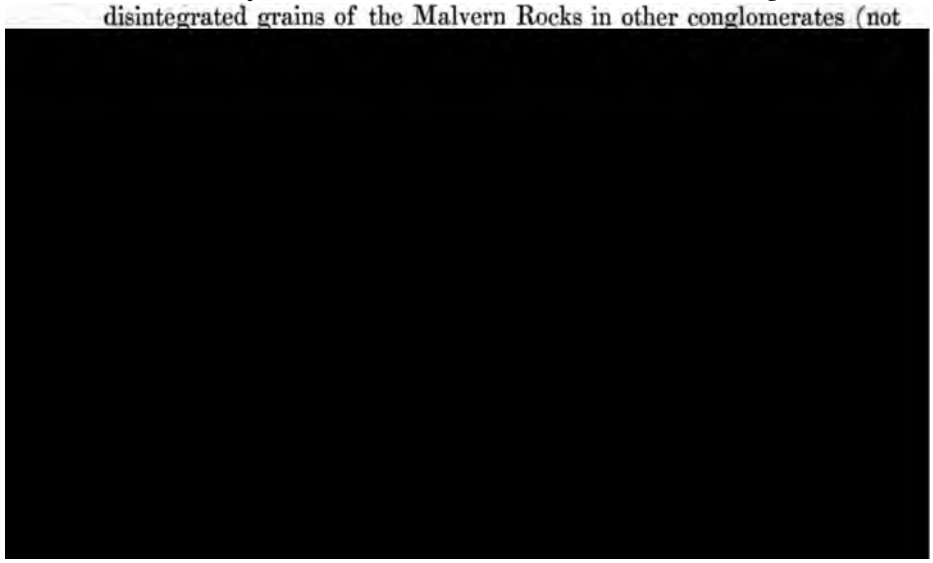
manner as commonly happens in shelly cavities in other conglomerates and sandstones far removed from the trap. Exterior to this very pebbly mass, the shells were equally numerous, but the rock fragments among which they lay were generally angular, appearing just as if they had fallen from a cliff upon a pebbly beach, and received into their interstices abundance of shells and sand drifted by the water.

The degree of *firmness* of the shelly masses thus examined *in situ*, is less on an average than that of the loose pieces on the hill-slopes which were first observed; these latter being the hardest portions which best withstood the destroying agencies. The shells, corals and encrinites, are commonly represented by casts and moulds, but a few specimens have occurred of Turbinolopsis, with the calcareous substance entirely preserved.

The pebbles and fragments of stone mixed with the shells, are of the same nature as the rocks immediately adjacent and composing the neighbouring hills; that is to say, characteristic compounds and segregations of hornblende, felspar, quartz, and mica, in great variety. The whole mass is stained by ferruginous admixtures, and at a small distance looks like some of the dark trap of the hills with which it is in contact. What may be its degree of induration at a considerable depth is unknown, the situation allowing only of an exploration to the depth of a few feet.

The just inference from the occurrence of the shelly conglomerate thus briefly described, appears to be that the syenitic and other associated rocks of the northern portion of the Malvern Hills were accumulated and indurated previous to the aggregation of the lower portions of the Caradoc sandstone series; and that they were, with the whole Silurian series, raised in a solid state.

In harmony with this conclusion, is the abundance of fragments and disintegrated grains of the Malvern Rocks in other conglomerates (not



constitution of even the Malvern Chain itself is sufficiently varied in its different parts, to induce a long pause before the apparently proved high antiquity of the northern syenites should be implicitly extended even to the southern portion of the same chain.*

To the above observations I have to add that in the spring of 1844, the first observer of this conglomerate found the means of tracing it to some distance farther northward, and obtained abundant additional evidence of the truth of all the conclusions above stated. In my subsequent examination it was evident that the surfaces of stratification were very irregular, *some of them ripple-marked*, that the coarse conglomeritic and brecciated character was confined to the near vicinity of the trap, the successively imposed beds showing less and less of large fragments, and a more distinct collecting of the fossils into planes, parallel to the strata. The conglomeritic character is probably as limited in its longitudinal range as in its vertical extent, so that but for the circumstances already narrated, the fact might for a long time have remained unknown, and the conclusions which it so strongly confirms have wanted a valuable link.

Among the organic remains which occur in this conglomerate were

Favosites multipora.
Turbinolopsis bina.
Dimerocrinites, in considerable perfection.
Orthis bilobata.
—— flabellulum.

The road leading from near the Poor-house on the Worcester road to Merry Mill and Birchwood, gives opportunity to confirm the general succession of the Caradoc sandstones, and the course of the Leigh Brook by Gunwick Mill discloses a good general section and a good series of organic remains. In the centre of the anticlinal arch which is crossed by the Leigh Brook, the purple beds below the upper Caradoc series appear east of the old mill, and on either side the Caradoc is overlaid by Woolhope limestone and shales. (Shales only appear, and those in a confused state, near Birchen Hall.) The Caradoc fossils are numerous; they are obtained from the lower part of the group near the mill.

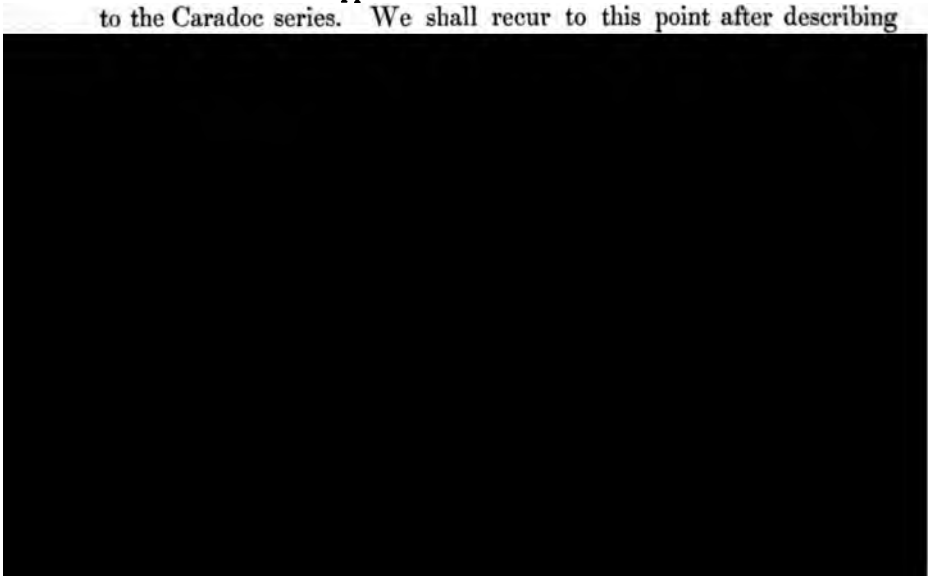
6. WOOLHOPE LIMESTONE.

Rough impure limestone, with or without intervening sandstones (thickness 10 to 150 feet).

On the upper surface of the gray laminated sandstones and shale last mentioned, lies a calcareous rock, of unequal thickness, but of such

* London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science for October, 1842.

continuity, that it is seldom deficient in any good section which shows the upper edge of the gray sandstones. We may call its average thickness in this district 20 feet: it is a broadly-bedded rock, but the layers are irregular, uneven and interrupted. The substance of the stone is somewhat argillaceous and its aggregation is more or less nodular. Ferruginous stains often discolour the natural gray tint of this limestone. Joints are numerous in it, and some of them are extremely long and regular. They are often lined by pink-coloured calcareous spar. The beds are always partially fossiliferous, and locally very rich in organic remains, as Trilobites, Terebratulæ, Orthocerata, &c. There is no chert in this limestone. Where gray shales lie above and gray sandstones with shales occur below this limestone, it seems almost a matter of indifference whether to rank it with the sandstones below, or with the shales above. But when, as happens often, the lower part of that argillaceous series is calciferous, there is no obvious means of distinguishing the limestones, thus brought together, except that the lower part is usually more broadly bedded, the upper parts more decidedly formed in nodular and undulated or ball-like masses. In this case then the Woolhope limestone can scarcely be separated from the Wenlock shale and would be naturally referred to the same great upper Silurian group. Possessed of this idea, which is strongly confirmed by the character of the organic remains in the rock, we proceed without difficulty through all the southern part of the Malvern district. But in approaching the northern parts a change appears. At Walm's Well the limestone is in two parts, and between them is a little laminated sandstone and shale; and below the Worcestershire Beacon, in the natural section so often referred to, these interposed sandstones of the usual Caradoc type, are between 80 and 90 feet thick; so that the limestone above appears referrible to the Wenlock and that below to the Caradoc series. We shall recur to this point after describing



30° and 40° to E.S.E. At a point east of Netherton, its long course to the N.N.E. ends, and it is subject to several little breaks and twists, the whole effect of which is to make a returning outcrop through News Wood, with beds dipping 45° to the E.N.E., on a line ranging to the S.S.E. This ceases near the Obelisk, and the outcrop returns (it is visible for a short length only) parallel to the Syenite of Swinyard Hill, to join (the precise manner is not discoverable) the outcrop of limestone a little west of Walm's Well. Here its strike is to the north 10° west, and its dip *reversed or to the eastward is* 40°. This is the first time we have had occasion to mention the reversal of dip, a phenomenon which is frequent in the points north of Herefordshire Beacon, but hardly to be quoted in a single instance, south of Walm's Well.

From the limestone near Walm's Well to the detached mass of it, which, dipping eastward, rests with Caradoc sandstone in the hollow pass between Swinyard Hill and the Hereford Beacon, is less than a quarter of a mile. Silurian strata connect or almost connect the two points, but the limestone cannot be continuously traced between them.

North of Walm's Well the limestone clings to the uneven slope of the Beacon Hill, and is seen frequently in the old narrow road, sometimes vertical, often dipping 50° E. or N.E. It cannot be traced completely round the most prominent parts of the hill which look out toward the north-west, but resumes its place (with nearly vertical or rather reversed dip) below Wind's Point, and there continues without a single interruption below Brand's Lodge, through Hawket Copse, by Stonesway, Mathon Park Copse, and east of Mathon Lodge, to the interesting section in the valley below the houses west of the Worcestershire Beacon, where the reversed position of the strata arrests attention. Thence east of Croft Farm, along the western sides of the High Wood, and Rough Hill Wood (the strata dislocated), near the Poor-house, east of Storridge Farm (dipping moderately to the west), along the western slope of Mullin's Copse, just above Batchcomb, through the wood, and across the road north of that farm.

In all this line its course is extremely plain, and it has been often slightly quarried, especially about Storridge. It crosses Leigh Brook, between Gunwick Mill and Mousehole Bridge, occupies an unusual breadth in the road north of it, continues by Herrington, crosses the Crewshill Road, with a moderate dip to the west, and reaches the parallel of Round Hill, where it is broken and displaced by the remarkable faults between that point and Knightsford Bridge. In nearly all this course its ordinary and characteristic position is on the westward slope of a hill of Caradoc sandstone. It is nowhere so wide as in the vicinity of Alfrick Pound, north of Leigh Brook, the dip there being moderate. On the opposite side of the anticlinal axis of Caradoc sandstone here, another

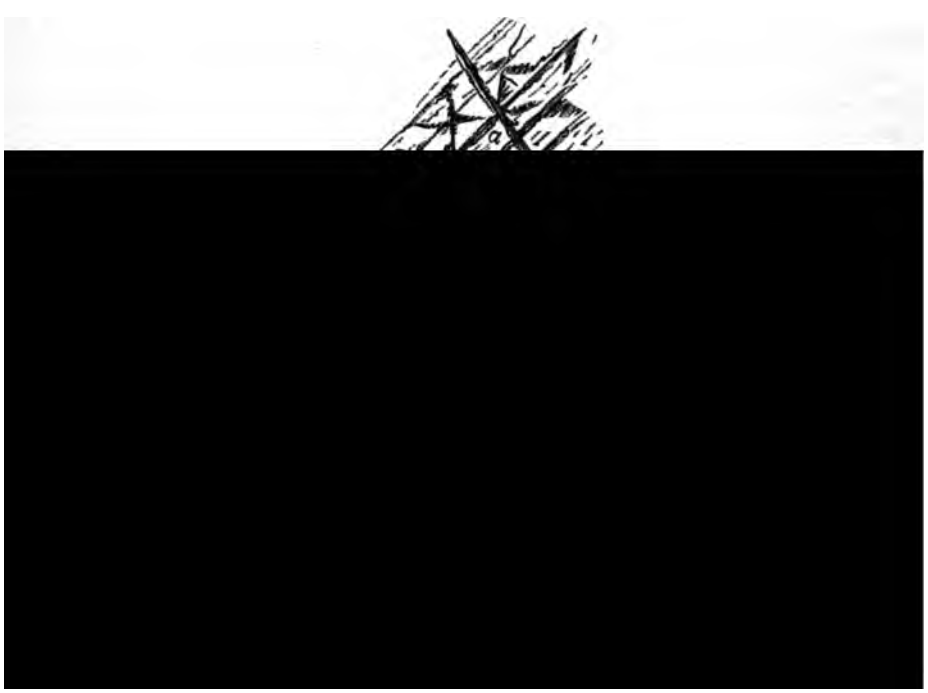
band of it is traceable for some distance, and appears in the road at Alfrick Pound, and at other points so near to the western band already mentioned as almost to cover entirely the summit of the anticlinal. Similarly on the eastern slope of the anticlinal Caradoc sandstone, between Storridge Farm and Holywell Turnpike, an eastern band of this limestone is seen in the road and in the fields.

We may now consider some of the facts observable at the most remarkable sections and quarries, which occur in the long line of Woolhope limestone just traced.

In the southern part of its course, on the eastern side of Glynch Brook, it appears to be of a nodular character, and of irregular thickness, a circumstance, perhaps, attributable to the universal prevalence of coral in the mass. (In the same district the Wenlock limestone is remarkably coralliferous.)

In the quarry in a field between Gold Hill and Hill End, the beds are very regular, and crossed by regular joints, in two directions, viz., nearly N. and S., and nearly E. and W.; the former nearly coincident with the strike (N. by E.), the latter with the dip of the beds (E. by S.).

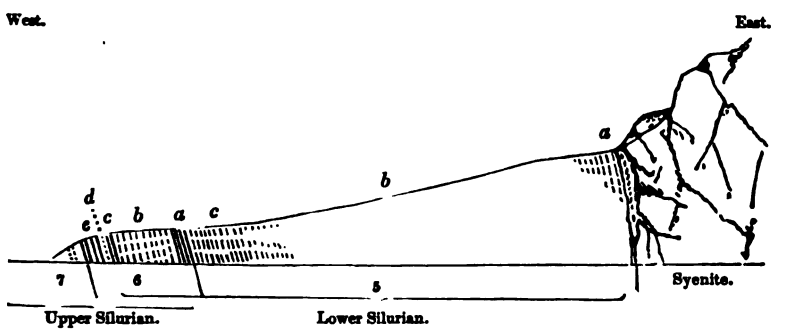
Again, the quarry in Stump's Wood shows the same limestone, more rough, coarse, and ochraceous, partly flaggy, and partly in lumps, with partings of shale. The joints are here, also, very regular and parallel, especially one set which passes along the strike of the beds (N. N. E.), to which others are nearly perpendicular. The planes of the former set of joints are not quite rectangular to the plane of stratification, but arranged thus in section, the angle (*a*) being less than 90°.



bands is nowhere above 20 feet, but the space occupied by them near Walm's Well, including the shales and grit, is greater.

The best and most interesting of all the sections, that beneath the Worcestershire Beacon, may now be described at greater length, commencing on the east, and proceeding toward the west, where the Mathon Park road crosses the little valley, in the lower part of the Wenlock shale, of which a thickness of nearly 50 feet is here exposed.

The following diagram may be consulted.



On leaving the syenite, with the conglomerate bed already described p. 66, we cross, as there stated, nearly 500 feet of Caradoc sandstones (5 *b c*), most fossiliferous in the lower part (*b*), and then arrive at a limestone band (6 *a*), succeeded by sandstones and shales (6 *b*), another limestone and shale band (6 *c*), shale bands with nodules (6 *d*), and limestone (6 *e*.) These are succeeded by the Wenlock shale (7). The beds are reversed, the upper dipping (for a short distance, probably), under the lower at an angle of 63°, on a strike to the N. 20° W.

No. 5 *c* is the ordinary thin-bedded, very slightly micaceous Caradoc sandstone and shale, in particular bands fossiliferous, but less so than in the lower parts (viz. 5 *b* and 5 *a*).

No. 6 *a* is the lowest calcareous bed here visible. It is about 16 feet thick, irregular and lumpy in stratification, ferruginous and shaly enough to render the mass very impurely calcareous. It contains fossils, especially the following:

POLYPIARIA	Cyathophyllum turbinatum.
BRACHIOPODA	Atrypa prisca.
	Orthis canalis.
	—— hybrida.
	Leptæna depressa.
	———— tenuistriata.
	———— sericea.
	Terebratula, n. s.
	Orthoceras annulatum.

No. 6 *b* is thin-bedded Caradoc sandstone and shale, like No. 5 *c*, between 80 and 90 feet thick.

It contains fossils, especially

Atrypa orbicularis.
Leptæna sericea, *var.* spinangula.

No. 6 *c*, is a series of thin flat-bedded sandy limestones and shales, two feet thick in all. These limestone bands resemble, as to their surfaces and general aspect, the sandstone beds below, and are associated with similar shales. No fossils were found in them.

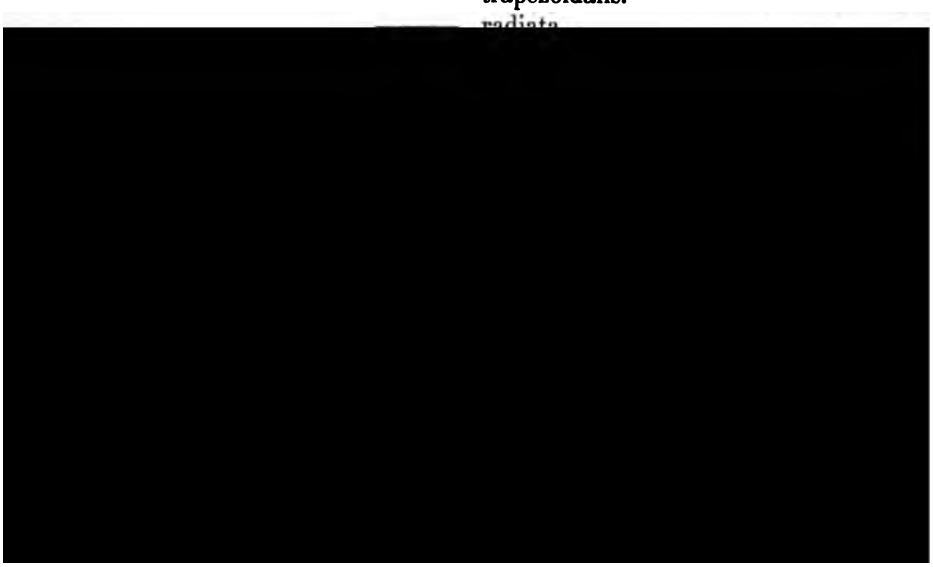
No. 6 *d*. Shales, with layers of subcalcareous nodules, 18 feet.

The calcareous parts yield corals, principally : as

Polypiaria .	Favosites spongites.
	——— multipora.
	——— alveolaris.
	Cyathophyllum turbinatum.
	Porites pyriformis.
Brachiopoda	Leptæna depressa.

No. 6 *e*. Sub-calcareous bands, lumpy, ferruginous, and shaly. These few irregular beds amount to about 25 feet in thickness, and contain a considerable number of fossils, as

Polypiaria .	Cyathophyllum turbinatum (small).
Brachiopoda.	Atrypa prisca.
	——— linguifera, the most abundant of all.
	Spirifera crispa.
	——— pisum.
	——— biloba.
	——— trapezoidalis.
	——— radiata.



the upper Silurians. If, following the Caradoc sandstones to their full extent, we raise the lower Silurian limit to the laminated limestone, 6 *c*, we shall include in the older Silurian period a deposit (6 *a*) filled with remains which predominate in a later period; and if, influenced by this consideration, we carry downward the upper Silurian limit, we shall interpolate among its characteristic limestones an arenaceous deposit whose physical history is very different, and which, by all its characters, belongs to the earlier group. This is a difficulty of classification merely; a difficulty which occurs in almost every part of the series of strata, and everywhere troubles our systems, but which is perfectly in harmony with the well-understood operations of nature. Just as in the history of nations the germs of new social systems may be traced, and may even have periods of activity and influence, before older systems have died away; and just as a banished race may return and possess for a time its old domains; so in the Silurian Sea, during a pause or diversion of the currents which drifted the Caradoc sands, the Woolhope limestones, which are the effect of the growth of shells and corals, began to appear; but the sand-drifts once again returned, before natural causes excluded them from the basin for ever.

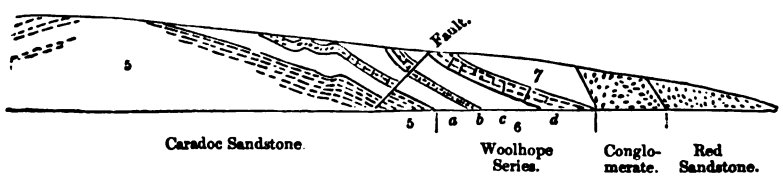
Though practically we *must* draw a line of division (and this is fixed *most conveniently*, so as to include in the upper Silurians the whole of the calcareous deposits), let us not forget, that in this locality there is really no firm and hard boundary between the lower and upper Silurian periods; for both by mineral and by organic evidence, the characteristics of these periods are found to *overpass each other, the older characters re-appearing within the later deposits, and the later characters showing themselves amidst the earlier deposits.*

As a general result, it is quite evident that the successive changes of organic forms, *as they are exhibited to us in the successive groups of strata*, are not simply dependent on the lapse of time, nor explicable as a series developed in proportion to the time, unless we survey the phenomena over very wide areas, and include in the comparative terms geological periods long enough to neutralise the influence of peculiar physical conditions. These, on account of their local origin, limited area of effect, and recurrence in different periods, have at almost every geographical point, at some epoch or other, broken or mingled the series of organic life. We shall find many other examples requiring the same explanation.

The Woolhope limestone is seen advantageously on both sides of the anticlinal ridge north of the Malverns: north of Crumpend Hill it dips east 9°, and north of Storridge Farm it dips west 32°. In the latter situation the Woolhope limestone is partly in level beds and partly in balls, with partings of shale, and is altogether 20 or 30 feet

thick. One of the beds was found (1842) covered with the caudal plates of *Asaphus caudatus*.

The Woolhope limestone is very well seen on both sides of the anticlinal about Crew's Hill and Alfrick Pound. On the western side the common boundary of this limestone and the Caradoc sandstone, is accompanied by a small dislocation. East of Alfrick Pound the road section, when fresh, showed a small fault through the Woolhope Beds, and the uppermost Caradoc layers, and the section was thus written down (1844). The dip is to the eastward 15° generally, but in particular places, where there are flexures, 40°.



No. 7. Wenlock shales, with layers of balls.

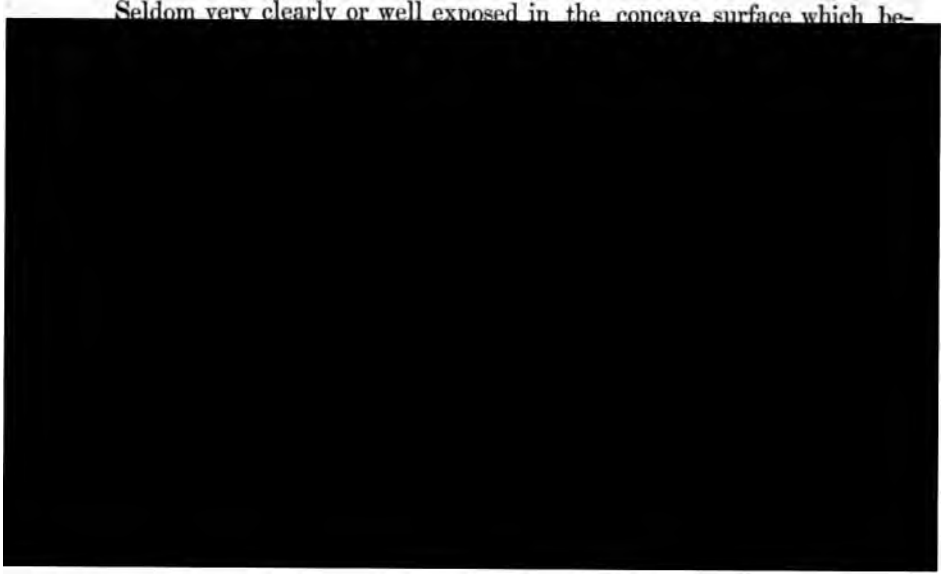
No. 6. { *d*, solid Woolhope limestone, a mass of calcareous and argillaceous parts, sometimes full of balls.
c, shales and thin bands or balls of limestone.
b, balls and bands of limestone.
a, shales and thin bands of limestone, with many small fossil shells.

No. 5. Caradoc shales and thin flat-bedded sandstones.

7. WENLOCK SHALE.

Pale soft shales and thin bands of limestone nodules (thickness about 640 feet).

This is a great mass of fine argillaceous sediments, without any important arenaceous admixture, but, especially in the lower part, containing many thin bands and courses of balls of argillaceous limestone. Seldom very clearly or well exposed in the concave surface which be-



the upper makes a bold edge on the west, overhanging the smooth hollow of Wenlock Shale.

From Netherton by Walm's Well, and round the Herefordshire Beacon, this shale, often dipping eastward, occupies a breadth of about 200 yards (or less); thenceforward it expands and contracts a little, takes a rather sinuous course, between Winning's Farm and Stonesway, and then continues in a nearly straight line to Croft Farm, where its breadth increases, but still does not equal a quarter of a mile. From this elevated point, the spectator, looking northward or southward, may mark the course of the Wenlock shale in a long valley between more or less wooded hills. Northward this valley widens, it bends and crosses the Worcester road, between Storridge Farm and the Cradley toll-bar, and then continues onward, broad, deep, and smooth, and margined by woods, by Batchcomb, Catterhill, Crews-hill, and Round Hill, beyond which it is cut off by a fault. Small patches of this shale appear on the east side of Alfrick Pound, west of Birchen Hall, west of Holywell turnpike, and about Cowley Park Farm, all on the eastern side of the anticlinal axis, which is continued to the N. N. W. of the Malvern Hills.

There is no place south of the Herefordshire Beacon where good sections of the Wenlock shale can be seen, and only where roads have been cut into it, or along the sides of rivulets, can it be much explored in localities north of that point.

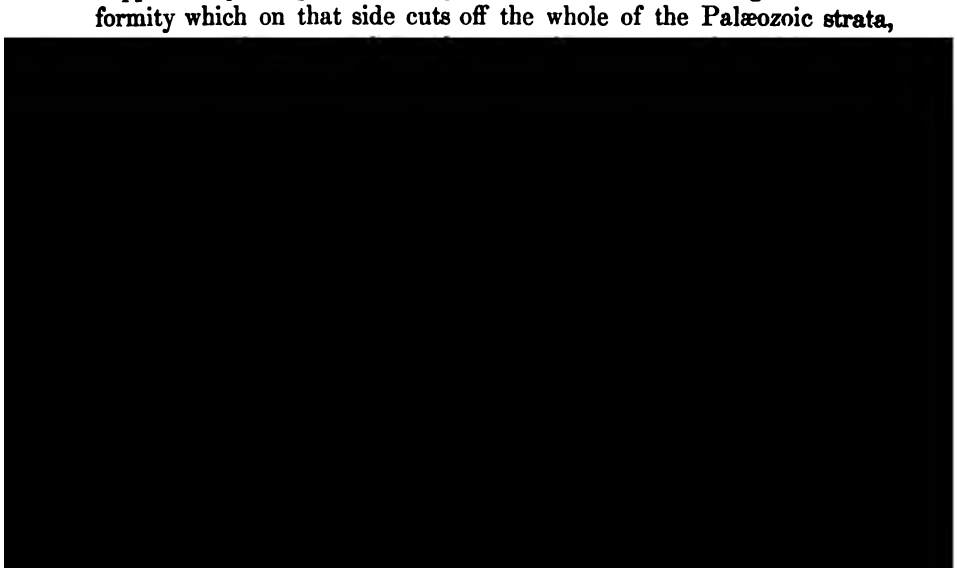
Between Old Castle and Wind's Point, below Brand Lodge, near Stonesway, and in Colwall Copse, some useful notes may be taken. The lower beds have been already noticed in the valley west of the Worcester Beacon; they may be seen again on the side of the Worcester road, and in the lanes about Storridge Farm; between Storridge Farm and Holywell Turnpike; about Crumpend Hill; in crossing the road north of the farm of Batchcomb; about Catterhill, Oughton Wells, east of Alfrick Pound, and on the eastern slope of Wall Hills. It is on account of their superior induration that these lower beds are more apparent than the upper ones; an induration due to their concretionary structure, and to the courses of argillaceous limestone nodules, which, at intervals of from 18 inches to several feet appear in many situations, especially about Storridge Farm, where these beds dipping from 20° to 30° to the west, may be seen above the Woolhope limestone, which is succeeded by the Caradoc sandstone. In this situation, and in the road east of Alfrick Pound, and under the Worcestershire Beacon, the transition is so easy from the shaly and nodular Woolhope limestones, into the subcalcareous and nodular Wenlock shales above, that these strata are not in the least degree more distinct from each other than the Lias limestone and the Lias shales. They are not even so distinct

as these Lias limestones and shales often appear to be, and may with as much propriety be included in one natural group.

8. WENLOCK LIMESTONES.

Limestone in layers of nodules and irregular beds, interlaminated with soft pale shales (thickness 100 to 280 feet).

When completely developed, this group of rocks is of considerable thickness, and appears in two, three, or more stages, alternating with shales, and occupying, with these, altogether as much as 280 feet of thickness. But it frequently happens that the whole is reduced to one limestone rock, covered by and resting upon several bands of argillo-calcareous nodules. In all cases the limestone rocks appear so naturally connected with the shales above and below (through the calcareous matter in these and the shales which interlaminate the rocks), that when they are absent or untraceable there is, perhaps, no real, and certainly no obvious mineral distinction between the upper and lower argillaceous masses. It is rarely composed of fragments of crinoidal columns, but often contains concretionary masses, from $\frac{1}{20}$th to $\frac{5}{10}$ths of an inch across, resembling the pisolitic masses of the Oxford oolite, and having a fibrous, radiated, and concentrically lamellar structure. This composition may be verified along almost the whole range of the limestone, from the Teme to Clincher's Mill. The limestone is yellowish externally, and internally of a smoky gray—locally red, white, and blue, or purplish. The most remarkable instance of peculiar colouring in this rock, is on the south side of the Ledbury district, where, in contact with, and for a breadth of some hundreds of feet on a sloping surface, the rock is stained purple or red in its very substance, as well as in the joints. This happens only along a breadth parallel to the line of the great unconformity which on that side cuts off the whole of the Palæozoic strata,



than in the solid limestone beds; but there is little of constant peculiarity in this respect.

The divisional planes of the limestone are rather conspicuous, and sometimes become regular joints, open or crusted over by white and pink-coloured calcareous spar. In some cases the surfaces lined with such spar are marked by *lines parallel to the dip of the beds* (Eastnor Park). There is no chert in this limestone.

The course of these calcareous strata is most easily followed, as they generally form a narrow ridge of considerable elevation and (allowing for the transverse valleys) great continuity. Commencing at the mill (called Clincher's Mill), south of Eastnor, we find a considerable limestone rock in thin, irregular beds, extensively quarried on both sides of the Glynch Brook, with a dip to the W.S.W. of 18°, and in one place of 30°. Spreading out to the west, through the woods, it sinks and rises again into narrow anticlinals, partially or entirely separated by hollows of the superincumbent shale. These anticlinals range nearly north and south, and, being in a considerable degree covered by woods, are not to be completely traced without difficulty. From Woolpit Farm, one line may be traced northward about half a mile, and again, after a little interruption and slight flexure to the eastward, for some distance farther, in each case near the eastern side of the woods. Two other ridges may be examined east of Ledbury, one of which crosses the main road, and is quarried extensively; the other, which is on a line of elevation passing through Rilbury Camp, does not extend to the road. It is also largely quarried in fields north of Coneygre Wood. By taking the footpath from Ledbury to Eastnor, the two last-mentioned ridges may be crossed; the first-named lies more to the south.

From Clincher's Mill, however, the main line of the limestone passes to the northward, on the western side of the Glynch Brook, and is quarried, by the road side, west of Gold-hill Farm and near Eastnor Castle. It cannot, however, be completely traced from Clincher's Mill even to Gold-hill Farm, for the place of its outcrop is partly covered by gravel drifts of considerable thickness and extent. (See Diagram on p. 15.) There is, perhaps, also some dislocation crossing the line of outcrop, for the beds in the great quarry at Gold Hill are somewhat arched and dip to the S.W. 22°.

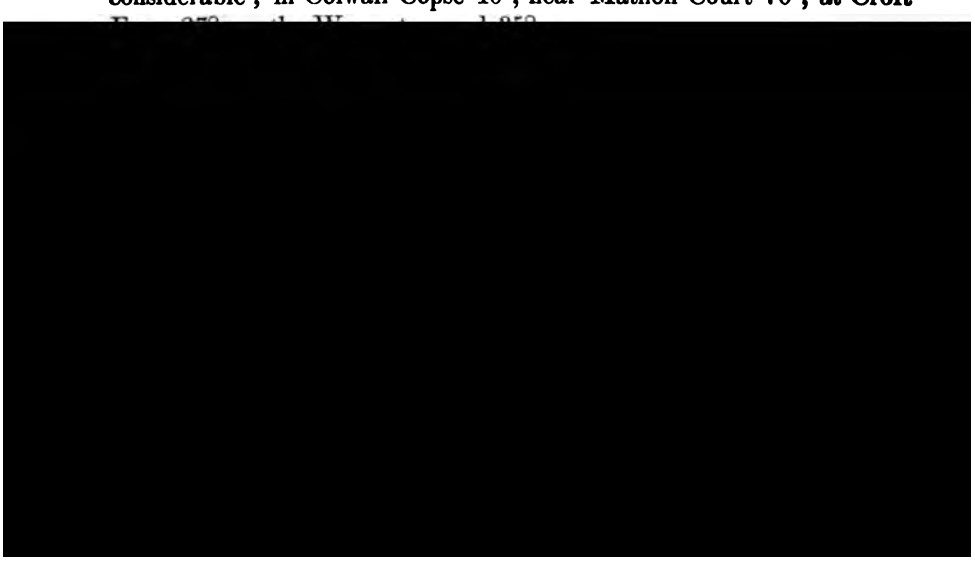
From Eastnor Castle the course of the limestone for two miles is extremely remarkable and prominent, constituting what is appropriately called the Ridgeway. This is a crescent-shaped, narrow hill, mostly covered with wood, along which, among fine yews and firs, a pleasant drive leads from the main road near Wind's Point to Eastnor. On either hand is a broad, smooth valley, formed in shale, and the dip, which is first to N.N.W., then to N.W., and afterwards, near Awk-

bridge Farm, to N., being steep (from 20° to 35°), the two sides of the Ridgeway are almost equally abrupt, and it has very much the appearance of a gigantic ancient earthwork.

Between Awkbridge Farm and the Hereford Beacon, the outcrop of this limestone returns to the south; in some places the beds are vertical, and many parallel calcareous bands are seen, which have been worked in the woods. One great quarry is now open. This inflexion to the south, the beds dipping to the W.N.W. (32°), is part of the same synclinal trough which has been already noticed while speaking of the range of the Woolhope limestone near the Obelisk.

In its prolongation northward, the Wenlock limestone runs nearly north and south, from points west of Walm's Well to some old quarries on the road side between Eastnor Lodge and the Hereford Beacon. It then turns to the N.N.E., down the steep descent to the low ground east of Old Castle; thence it rises again, and runs in a narrow course (the beds being vertical or very highly inclined to the west), in higher, mostly woody, ground, toward Winning's Farm, which it reaches rather obscurely by a singular twist to the N.N.W. (dipping to the W.S.W. 43°). The line of this twist is, in fact, a line of fault, which will require further notice.

From Winning's Farm the Wenlock limestone turns again to the N. E. (dipping N.W. 40°) till it approaches the syenite, parallel to which it then ranges N.N.W. along some interrupted, mostly woody, crests, by Colwall Copse, where it is quarried, Mathon Park Farm, Castle Copse, Croft Farm Limekilns, and the high woody ridge which crosses the Worcester road near Cradley Turnpike. In this course, it grows wider and wider towards the north, as far as the Worcester road, before reaching which, in Whitman's Hill, it undulates, and thus expands to above 500 yards in breadth. The dip is westward, and always considerable; in Colwall Copse 40°, near Mathon Court 70°, at Croft



Malvern Hills, the Wenlock limestone appears as the highest Palæozoic stratum, and is largely quarried about Holywell Turnpike, and slightly so in Mill Copse, north of Cowley Park Farm.

The economical value of this rock, in the Malvern district, is great, since it almost exclusively supports the very extensive and continual demand for lime in all the neighbouring agricultural regions, eastward, westward, and southward. On this account, limekilns abound along its range from one end of the district to the other—from Clincher's Mill to Wall's Hill—and, owing to the steepness of the dips, the quarries usually range in narrow continuous lines along the crests of the hills, from which the roads are seldom good.

It has been already observed, that the Wenlock limestone, in some places a single solid bed, covered by calcareous nodules, is accumulated in other localities, to a double or even triple series, all more or less suitable for the lime-burner. As a general rule, it is to be concluded, that in the northern parts of the district the lowest of these bands is almost everywhere the favourite rock. This is the rock now burnt at Colwell Copse, where the whole Wenlock series is 280 feet thick, and divisible into several bands, and at Croft Farm, where the lower divisions occupy 150 yards of surface, and are succeeded by a distinct upper band. The upper solid rocks are quarried about Eastnor and Ledbury.

On account of the importance of this rock to the agriculture of the district, it appears desirable to record the principal peculiarities which have been observed in the course of the survey of the many quarries and natural sections which it offers. We commence, as before, at the southern extremity, viz., near to Clincher's Mill on Glynch Brook.

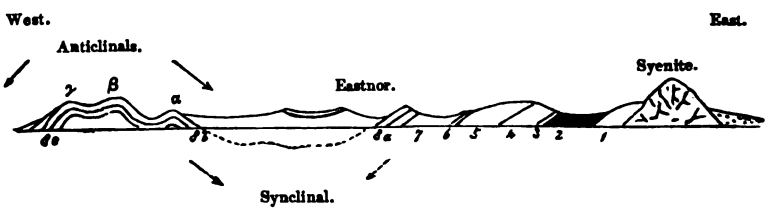
On the east side of the brook is a large quarry of limestone of a purple or gray tint internally, alternating with purplish shales, the tint being much redder on the bedding surfaces and in the joints of the rocks, especially toward the surface of the ground. On the surfaces many small corals abound. The beds strike to the N., 30° W., and dip S.W. 18° or 20°. The lower part is solid, the upper part nodular and shaly. Joints of much regularity divide the solid rock. Only a few yards to the southward, is the new red conglomerate and sandstone; and there is no doubt of its having formerly extended over the limestone and communicated the red tint to the joints and other divisional structures.

On the west of the stream the limestone shows itself, and is quarried. In the higher parts of the wood it is of the usual light gray tint (dipping E. 30°), but in the lower ground, and farther to the south, the limestone and the shales are much stained with red and green tints. Here they strike to the north and dip eastward 30°, and are covered by a red soil, which appears (at intervals) up the course of the Glynch,

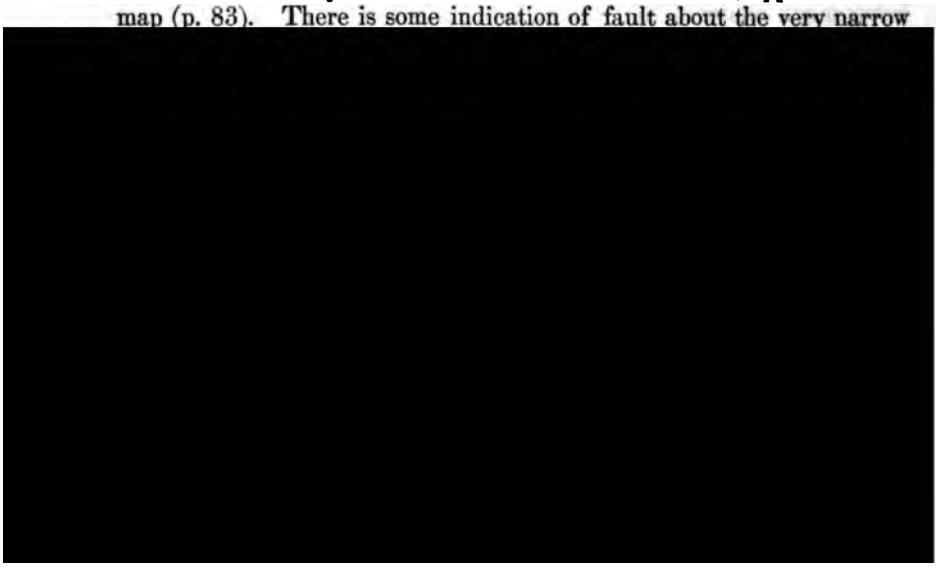
and up the Eastnor valley, even as far as Eastnor Church. This, perhaps, indicates the ancient extension of new red strata up the hollow. Corals abound in these rocks.

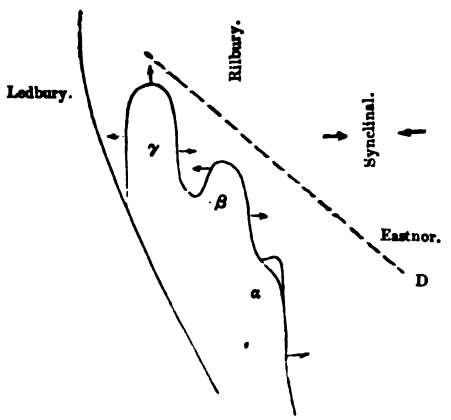
At Woolpit's Farm, N.W. of Clincher's Mill, the limestone appears in broad surfaces, ranging N. and S., and highly inclined to the E. (62°) Here are many corals amongst the numerous calcareous nodules.

The relative position of the limestones near Ledbury and Eastnor requires the aid of a diagram.



In this diagram, Nos. 1 to 7 represent strata which have been already described, and which all dip toward the west, or *from* the Malvern ridge. No. 8 is the Wenlock limestone, which, as it first appears (8 *a*), strikes N.N.E., and dips westward (16°), and when seen again (8 *b*) rises into several anticlinals, so as to form a syclinal basin here about a mile broad, but widening as it proceeds northward, and growing narrower to the southward. Between the point marked 8 *b* and that marked 8 *c*, may be traced two synclinals and three anticlinals, α, β, γ, which, after continuing some distance to the northward, sink down and end in digitated protuberances. On their prolongations large quarries are established; and by inspecting them, and the appearances on the footpath from Eastnor to Ledbury, the truth of the above diagram will be established. The area covered by the limestone, thus shown in section, appears on the map (p. 83). There is some indication of fault about the very narrow





The ellipsoidal form of the northern part of the anticlinal which is nearest to Ledbury, may be satisfactorily seen by following the circuit of the great limestone quarry north of the Worcester road and the sections in the adjoining roads. This regularly arched elevation is crossed by one of the lines of section to the sea-level (Sheet 13, No. 4).

About Eastnor Castle, the limestone strikes to the N.N.E. and lies with a moderate dip to the westward (16° to 20°). Near the castle and in the park, north of it, are large quarries, the stone being regularly bedded and jointed. In the park, the following measures were taken:—

Strike of Beds N. 25°, E. dip to W.N.W. (16°)
„ Joint α N. 55°, W. dip to N.E. (80°)
„ Joint β N. 37½°, E. dip to S.E. (75°).
(Average of three observations.)

The joint marked α is the most regular.

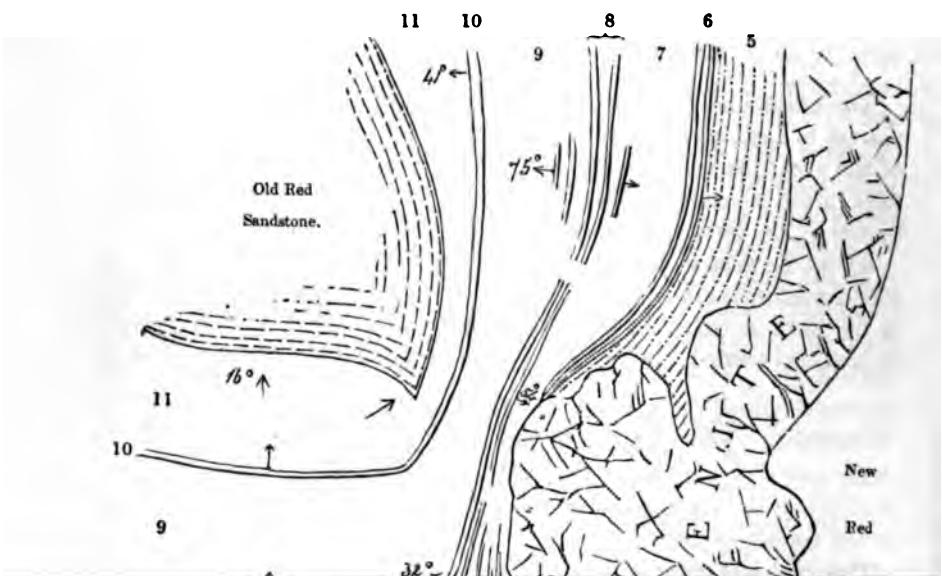
The complicated, but very interesting sections of the Wenlock limestone, which appear about the Herefordshire Beacon require a diagram to be properly understood.

By the side of the turnpike-road from Malvern toward Ledbury, north of the Hereford Beacon, we find, not far from the trap, the Wenlock limestone dipping eastward, that is, toward the trap (54°). The limestone bands appear here gathered into one principal mass. But, taking another course from the syenite, viz., from Walm's Well along the bridle road toward the W.N.W., we find (after passing the Woolhope limestone, in two divisions, dipping eastward 32°) no less than seven bands (some being solid limestone, and some only calcareous balls), which generally range N. 10 W°., and either dip to the westward or appear nearly vertical.

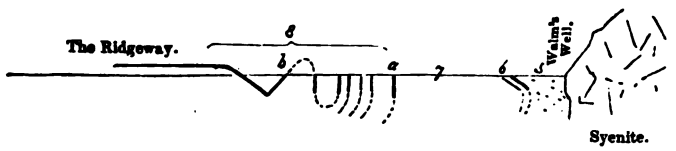
A little farther west, these beds, or some of them, return at first in a nearly parallel course, dipping eastward, and then bend round so as to dip northward.

The map-diagram (p. 84) shows this singular arrangement, the stratified rocks being marked in it by numbers, according to the following list :—

11. Upper Ludlow
10. Aymestry Rock
9. Lower Ludlow
8. Wenlock Limestone
7. Wenlock Shale
6. Woolhope Limestone
5. Caradoc Sandstone.

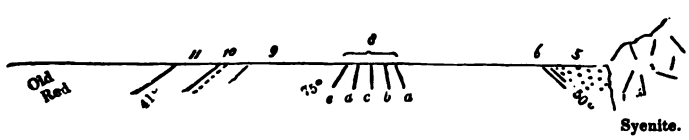


The section across these beds appears as under, the dotted lines being



added to show the probable connexions and continuations of the parts. The dip of the bed at *a* is to the west (80°), that at *b* (in the great quarry) also westward (32°). The distance between *a* and *b*, measured across the strike, is about 250 yards. It cannot be ascertained that the curvatures are *exactly* as above represented; but there is no reason to think there are here so many as seven calcareous bands, and no difficulty in admitting that the beds may be bent in sudden and violent curvatures. The best limestone appears to be at the *top* of the series, and so it is farther south, as about Eastnor Castle and Gold-hill Farm. All these limestones appear to cease on the south, before reaching the little valley which runs down from Walm's Well to the west; perhaps they are not cut off by a fault, but have, by turning upwards, reached the surface, and so terminated the trough. (See the coloured map.)

In the same map-diagram, farther to the north, we trace a somewhat similar phenomenon, viz., a series of five nearly parallel bands of limestone and calcareous balls, connected with the bands already described, near Walm's Well, by a double line of calcareous outcrop. These may be seen on the line of road which passes from Brand's Lodge to Evendine, and in the section might appear thus, the beds in the middle of



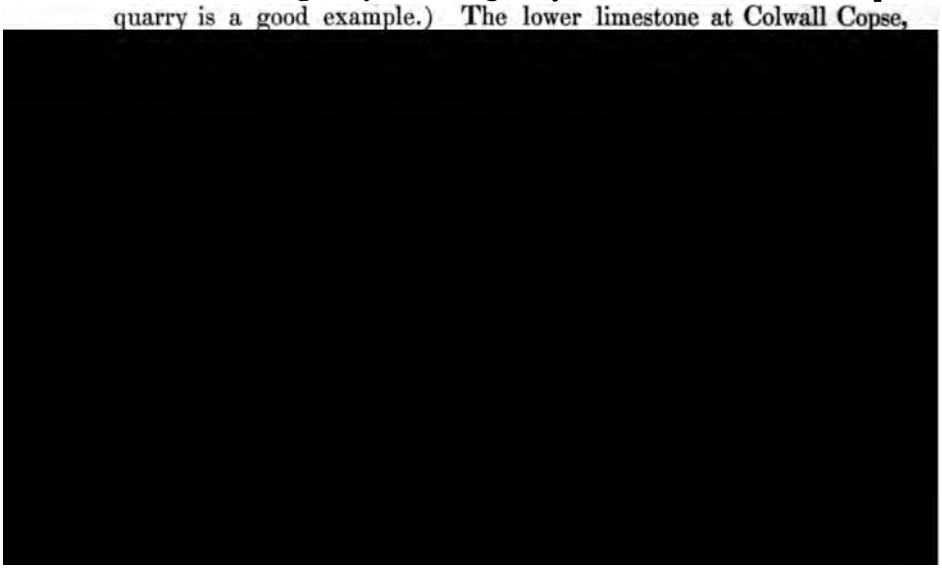
the Wenlock limestone (8) being nearly vertical, but those on each side dipping away from them. The strike of these beds is generally N.N.E., the breadth they occupy on the surface from 100 to 150 yards (being widest toward the north). The bands marked *b* and *c* are continuous and on the south run up to join the Eastnor beds under the Herefordshire Beacon.

In Colwell Copse we find the limestones lying with a very regular dip to the west (40° ±) and sufficiently exhibited to allow of pretty accurate measurement: measured on the surface of the road, the whole calciferous series is 550 feet across, and when the reductions are applied for the dip of the beds (35° to 40°) and the slope of the surface, the total thickness cannot be taken at less than 280 feet. This great mass

includes, however, a great proportion of shale and calcareous nodules, the series being as under.

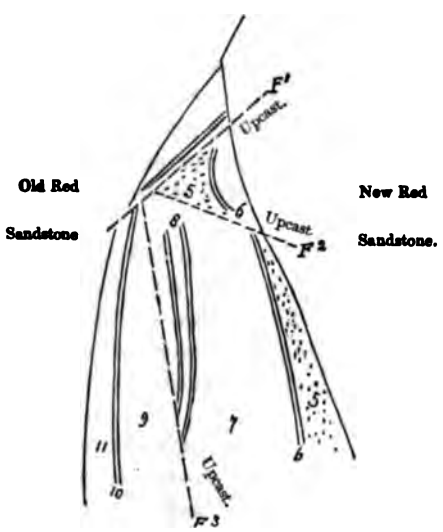
	Feet.	
*Limestone in nodular beds	10	
Shale and nodules	15	
Limestone in nodular beds	5	
Shale and nodules	110	
*Limestone in nodular beds	10	anciently worked.
Shale and nodules	100	
*Limestone in nodular beds	30	in a quarry.

The two lowest of the limestone bands, with the intervening shales and nodules, are seen again in narrow excavations north of Mathon Lodge, dipping westward (70°), and occupying 170 or 180 feet in surface breadth, or 150 feet of thickness. The upper portions are not distinctly traceable there. At Croft Farm the breadth of the limestones and their accompanying bands of nodules, is much greater, on account of the slope of the ground. The series resembles that at Colwell Copse. The strata dip 27° to the west, and the ground slopes about 10°. Hence, the surface breadth being nearly 300 yards, the thickness is about 250 feet, of which the lower portion (with the two beds of Mathon) is about 150 feet. About the same total thickness arises from the measures of the series in the hills farther to the north, two or three limestone bands being more or less distinctly traceable, of which generally the lower one is most extensively worked. Near Cradley Turnpike, three bands may be traced, the lower most conspicuous. They occupy about 120 yards breadth, dip from 40° to 56°, and may be 250 feet thick in all. They are all liable to degenerate into merely nodular masses, mixed with shale, and, indeed, the most apparently solid limestones are really little else than associated and connected nodules; and hence the bedding surfaces are singularly and irregularly undulated. (Colwall Copse quarry is a good example.) The lower limestone at Colwall Copse,



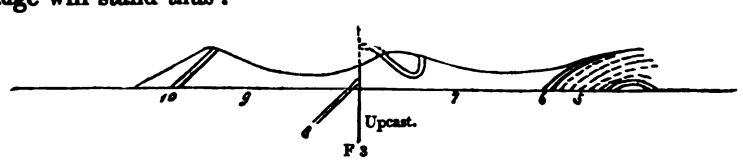
40° ±, the other being vertical, while the Aymestry rock (10) dips W. (50° to 70°), and the Woolhope rock (6) dips W. (26°). Now, by tracing these bands with care, we find them to converge continually southward, and apparently they unite below, as the dotted line indicates. This synclinal disturbance affects the Wenlock ridge in its course, farther to the north, where the section across the hill is in this form, dots being added to complete the lines below.

The beds 8 *c*, dipping E. 40° to 60°, 8 *b*, dipping 80° to 85° E., and 8 *a* being vertical. In some parts four calcareous ridges appear. The map of this district is in the annexed form, with two ascertained fault



lines (F^1 and F^2); and the singular positions of the beds in the ridge of the Wenlock limestone appear to require a third (F^3) in a line N.N.W., its effect being to elevate the eastern side.

With this addition, the section (taken generally) across the Wenlock ridge will stand thus:



the dotted part of the anticlinal having been in a great measure, but not entirely, removed by denudation. We find this principle applicable to the

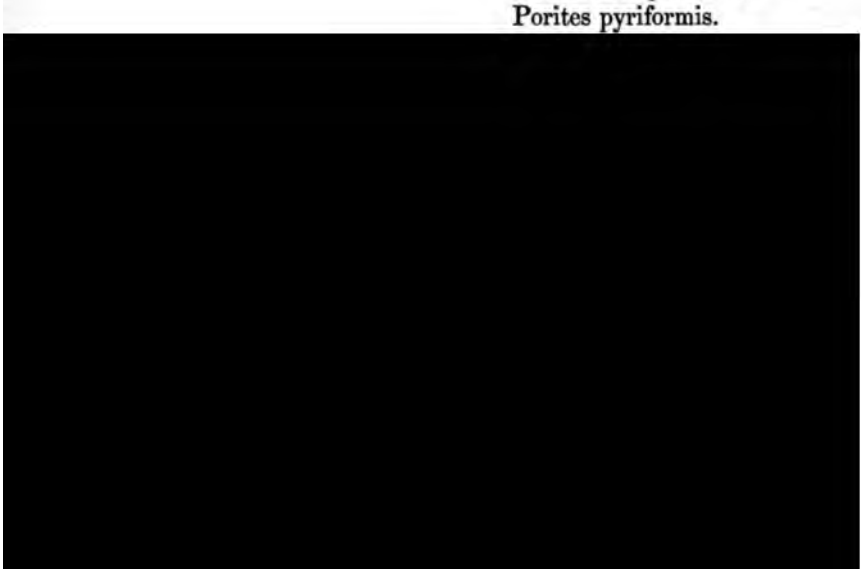
still more curious cases of anomalous dips in the Abberley Hills, l after to be noticed. The limestone of Wall's Hill is thus found t a synclinal capping only.

The lime burnt in the Malvern Hills is sold at about 8*s*. the ton might be afforded for less, if coal were cheaper. The usual propo of coal to rock (one in three or one in four) obtains. The choice o different parts of the rock by the lime-burner is somewhat capric Near Holywell Turnpike, the lower of two bands, which lies in pretty regular beds, is not burnt, as being of "too rough a grit:" shelly and crinoidal parts of the rock are not rejected; but the com solid stone is preferred. The general quality of the lime is exce for building and for agriculture; and the argillo-calcareous balls m it is very probable, be specially employed for water-cement.

The organic remains found in the Wenlock limestone of the Mal district are numerous, and are, without much constant difference, s tered through all parts of the mass. The most prolific surfaces fossils are generally in the comparatively loose "head," or top cove balls and shales; at least, it is in this part that certain of the specii are usually obtained in the best preservation as corals, the nume Brachiopoda, Gasteropoda, and even Trilobites. Orthoceratites perhaps, an exception.

The fossils of the Wenlock limestones form a large and character group, distinct, as a whole, from those of the Caradoc Rocks below, (less remarkably, however) from those of the Ludlow rocks at The following list includes a great proportion of the species which commonly observed in the Malvern district:—

POLYPIARIA	Cyathophyllum turbinatum.
	Strombodes plicatum.
	Porites pyriformis.



Conchifera, Brachiopoda.	Orthis elegantula.
	——— canalis.
	Spirifera octoplicata.
	——— radiata.
	——— crispa.
	——— biloba.
	Atrypa prisca.
	——— galeata.
	——— tenuistriata.
	——— linguifera.
	Terebratula nucula.
	——— Wilsoni.
	——— sphærica.
	——— Stricklandi.
	——— imbricata.
	——— cuneata.
	Leptæna euglypha.
	——— depressa.
	——— transversalis.
	——— lepisma.
Mesomyona .	Avicula lineata.
	——— retroflexa.
Gasteropoda	Euomphalus funatus.
	——— discors.
	——— sculptus.
	Nerita haliotidea.
	Loxonema sinuosa.
Pteropoda	Conularia Sowerbii.
Heteropoda	Bellerophon Wenlockensis.
Cephalopoda	Orthoceras Brightii.
	——— annulatum.
	Lituites Biddulphii.
Crustacea	Dalmania caudata.
	Calymene Blumenbachii.
	Odontopleura bimucronata.
	Nuttainia bulbiceps, (n. s.)
Annelida	Cornulites serpularius.

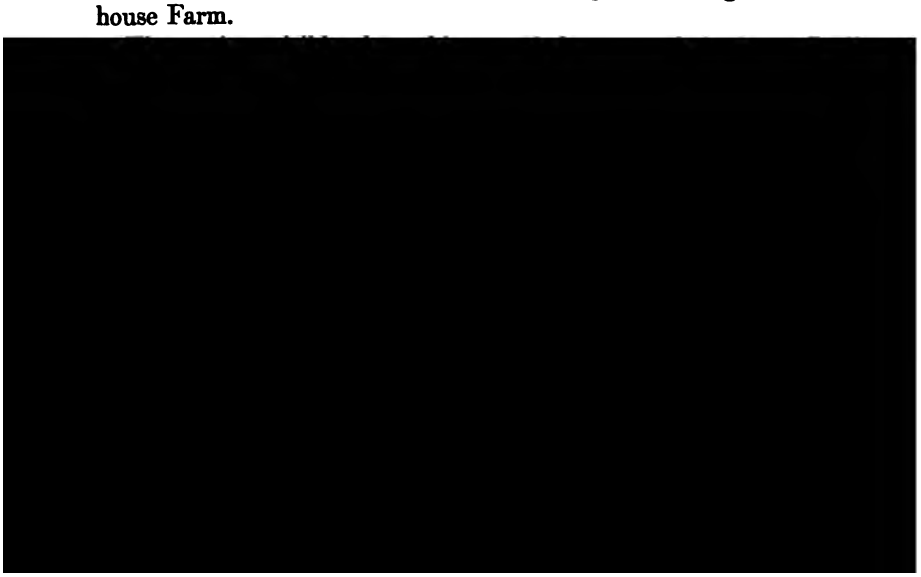
9. LOWER LUDLOW SHALES.

Gray shale, with argillaceous and calcareous balls in layers (thickness 700 feet).

In the lower part of this thick deposit, the shales are laminated, and of a determinate rather dark gray tint, with argillaceous balls, and some

bands and nodules of argillaceous limestone. The middle portion contains argillaceous nodules; the upper beds become more flaggy. Organic remains are in some places exceedingly plentiful in the lower portion, within 50 or 100 feet of the subjacent limestone (Eastnor). The brickyard east of Ledbury is situated on the lower part of these shales.

The course of the lower Ludlow shale may be traced in road cuttings from a point east of, and near to, Ledbury, mantling round the north side of the great quarry there, with dips W. N. and E., passing by the brickyard, to Eastnor Hill, and along the west side of the high ground which reaches thence towards Clincher's Mill. Hence it returns on the east side of that hill, to the hollow west of Gold Hill Farm and Eastnor Castle, dipping west. In this hollow it is well exposed, and yields many fossils. It then ranges along and fills the continuous valley between the Ridgeway and Sitch Wood, passing round between Awkbridge Farm and Chance's Pitch, and crossing the Worcester road, between the turnpike and Eastnor Lodge. (Beds of argillaceous balls appear here vertical.) Between Old Castle and the Hereford Beacon it is very well exhibited, the dip generally reversed to the west; thenceforward to Winning's Farm its course is plain, but the beds are seldom exposed. In the water-course from Colwell Copse to Brockhill, this shale, with included argillaceous balls, is extremely well exhibited for a considerable part of its thickness, in a hollow between the ridges of Aymestry and Wenlock limestone, the dip being westerly (about 35°). Similar features accompany it to the northward below Mathon Lodge, by Bank Farm, where its westward dip is 21°, and by Vine Farm, where it is cut through in the lanes, and may be well studied, the dip being 60°, or more to the west. Hence to the northward it is but little exposed in its narrow course between the hills to Batchelor's Bridge, Tundridge, and Blackhouse Farm.



from Old Castle to the Hereford Beacon, in vertical or reversed dips. The middle of the series is *well* exposed, and the upper and lower parts may be less completely examined (in a space of 400 yards), between Brock Hill and Colwell Copse. In these situations, the general uniformity of the dark gray shaly mass is the most striking character; and organic remains are somewhat sparingly found in it. Similar facts appear about Bank Farm and Vine Farm, in the vicinity of which the shales are largely exposed. (A phragmoceras was noted here.) S. E. of Halesend Farm the upper beds appear below the Aymestry limestone.

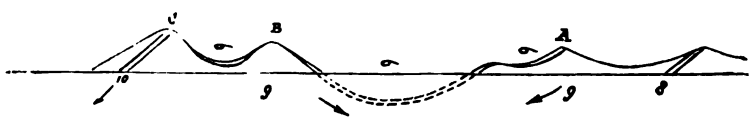
10. AYMESTRY ROCK.

A series of beds partly shaly and partly calcareous, so as to constitute a peculiar rock, full of irregular concretionary nodules of limestone. There is no chert in this series. (Thickness 10 to 40 feet, exclusive of the passage beds above and below).

No rock in the Malvern district has a more conspicuous general course, than the Aymestry bands, where they crest the long ridge near the extreme western border of the Silurian surface; none is so difficult to trace through all the windings produced by the many interrupted undulations into which the country is thrown. Referring to the map on which these are marked, as far as could be done with accuracy, in narrow blue lines, we may select for the purpose of guiding the observer the largest and most continuous lines, and add notices of the principal undulations and most instructive sections.

Commencing with the narrow woody ridge immediately north of Ledbury Church, and proceeding northward we find the section of this ridge in the road which leads to the Doghill Turnpike. The strike is here N. 15° E., and the beds are nearly vertical, or dipping west 80° and 85°; the beds being rather solid limestone, and shale with nodules. These beds continue (apparently less calcareous) along the high ridge of Bradlow Hill and Frith Wood, and may be traced into the lower and more broken ground of Hope End Park. Let this be called the Frith Wood line, dipping westward (c). Returning again to the Ledbury and Malvern Road, we find on the eastern side of Rilbury Camp, the Aymestry limestone dipping to the north-eastward, 45° and more, and apparently connected in a curved line with the nodular calcareous beds at Whitehouse, which dip to the N. E. 26°, unite with the eastern slope of Eastnor Hill, and with the summit of the hills south of Eastnor Church. This line can be traced, quite satisfactorily, by upper Mitchell (dip E. 45°), Petty France, Sparrow Hill (dip 48° E.), above Old Colwell (dip E. 46°), to near Pound (dip E. 53°). Let this be called the Rilbury and Eastnor line, dipping eastward (B). Again starting from

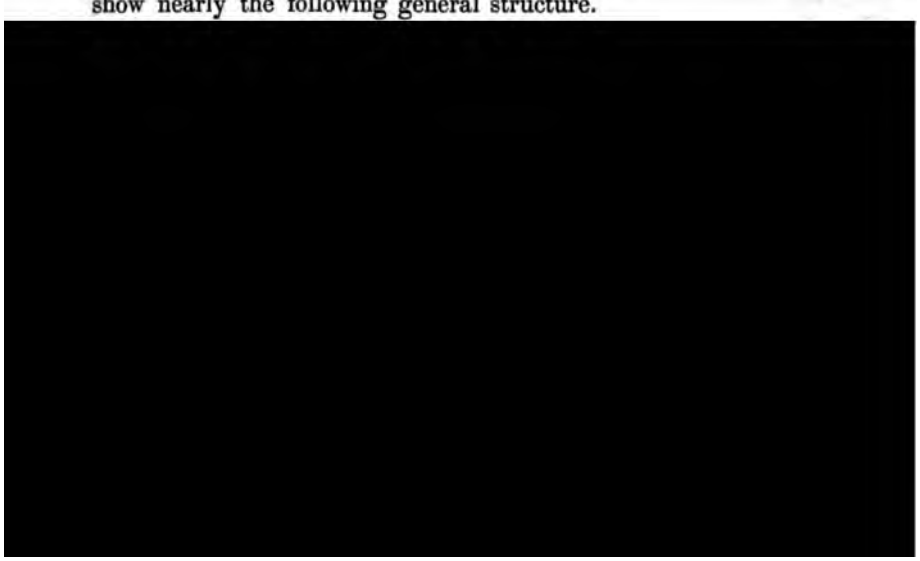
the hill which rises to the south of Eastnor Church, we trace a third long line, which is the real and final outcrop of the Aymestry rock, between Eastnor Church and the Somers Arms Inn, along Sitch Wood, and above Massington Farm to the turnpike-road near Chance's Pitch. This may be called the Sitch Wood line, and its dip is westward, generally about 30° (*a*). Between the Frith Wood and Rilbury lines, the space is, in a general sense, anticlinal, a continuation of the anticlinal ridges of limestone which are east of Ledbury; but it includes, also, a synclinal, most clearly traceable between Bradlow Hill and Rilbury Camp; there is, also, a small undulation on the west of the Sitch Wood line; and thus the section from Bradlow Hill to Sitch Wood presents the Aymestry rock in the following singular manner, viz.:—



with one very broad and two very narrow synclinals.

The district of Hope End is even more complicated. The Sitch Wood line (A) lies two miles east of it, the Rilbury line (B) runs continuously on its eastern boundary; the Frith Wood line (C), converging towards B, runs interruptedly through it towards Pound; and two new lines are added on the west, which we may call the Hope End line (D), and Raycomb line (E), the latter dipping to N. W., under the old red sandstone, and continuing to Comb Hill. Nor is this all; there is another anticlinal, still farther west, which forms the elliptical ridge of Raffnall Wood and Wellington Heath. On the western side it dips westward 56°.

A section drawn across the Hope End district, would, therefore, show nearly the following general structure.



ment, by peculiarities in the condition of the rock masses which have been disturbed.

Resuming the great outcrop line (A), where it encounters the hill of Chance's Pitch, we find it curve to the eastward, and continue along the road beyond the turnpike (with a northerly dip of 16°); after which it bends northward, and passes through the eastern part of Evendine Street, in a high ridge towards Winning's Farm. Here it is interrupted, and apparently shifted to the N. W. by the twist or fault already referred to, while speaking of the Wenlock limestone (p. 80), and re-appears in Brockhill, dipping W. 41°, and in a series of similar narrow woody hills, ranging N. N. W., the last and highest of which, N. N. W. of Bank Farm, is 852 feet above the sea.

Only half a-mile to the westward is another row of three hills, parallel as a whole, and nearly matching the three northernmost of those already described. Into these the line returns, so as to constitute an anticlinal, and exhibit the Aymestry rock and the Upper Ludlow strata, at Hall Court, and Rose Farm, and about Overley Farm. In the interval between the two lines of hills is a remarkable synclinal, dividing High Grove Hill. From Overley, northward, the narrow ridge of Lumbridge Hill (dip westward 50°, 70° and more), continues the line of this rock to the turnpike-road; three other narrow hills extend it to Longley Green; (dip westward 40° and more), from this it runs along the western ridge of the Suckley Hills to Blackhouse; about a mile beyond this point its long northward course is interrupted (probably by a fault); it veers to the N. E., crosses obliquely the general line of the hills, and terminates against the new red sandstone on the eastern side. There is no appearance of the Aymestry rock on the east side of the anticlinal ridge of Storridge and Rough Hill.

The Aymestry rock varies much in its aspect at the surface, yet has a pretty uniform character in deep cuttings. The deeper these cuttings the more blue and compact is the rock; nearer to the surface its constituent nodules became prominent, and at the surface they sometimes appear alone, through the decay of the connecting matter. As an example of the rock in a deep cutting, we may notice the quarry of road stone in the ridge north of Ledbury, near the Dog-hill turnpike, where for about 48 feet, dipping westward 77° or 80° the rock is deeply excavated along the strike, and appears as an impure solid limestone, in regular beds, having shales on each side, the dip growing steeper toward the west, and flatter towards the east.

Again, the rock is seen at the surface in Eastnor Hill, on the line of the footpath from Ledbury to Eastnor Church. Here it shows nodular limestone bands in subcalcareous shale, with a dip of 40° to the east, and a thickness of 40 feet. (See diagram, p. 82.) The rock is here

seen on the ends of the beds, and is less calcareous than at Ledbury. A very extensive exhibition of these beds appears on the turnpike-road at Chance's Pitch, in cuttings and quarries of a few feet in depth.

Here the tint is generally brown, the rock is regularly bedded and jointed, and the whole is evidently a mass of indurated subcalcareous sediments, in which balls, nodules, and ramified lumps, more calcareous than the other parts, abound. The great joints cut through these balls with a smooth and even section. The shales above and below differ by easy gradations from this rock, which in the Malvern district very seldom deserves the title of "limestone," and differs much from the corresponding rock in Shropshire.

It is not in general very fossiliferous. At Evendine, in certain layers (dipping W. 41°), *Leptæna depressa* abounds.

It is only necessary to add the section of the Aymestry bands, as they appear in Hale's-end quarry. (See the entire section, hereafter.)

		Thickness in feet.	
11. Upper Ludlow flaggy shales.			
Passage beds.	Do. with calcareous nodules in abundance	24	119
	(Layer of Terebratula Wilsoni).		
	Do. with calcareous nodules in abundance	20	
10. True Aymestry Rock, consisting of solid nodular calcareous beds, with many corals in the upper part; and shale partings between the irregularly undulated beds		22	
Passage beds.	Shale, with but few calcareous nodules	12	
	Shales, alternating with solid limestone in flattened nodules or thin bands	41	
9. Lower Ludlow shales.			

The lower passage beds have been slightly noticed at Brockhill, and they occur in several localities further north, but are less commonly found in the districts of Eastnor and Ledbury. They may, however, be traced in Eastnor Hill, and in the hill south of Eastnor Church.

faces assume more and more of vermicular and other inequalities, the rock becomes a brown and then a dry gray or white flaggy sandstone rarely containing organic remains, more than a few specks of coal, portions of plants, and one species of Lingula.

With this rock alternate a few reddish layers, argillaceous, and arenaceous, and by this process of change, the brown gray and white sandstones and gray shales are at length replaced by red arenaceous sandstones and shales of a decided dark red tint, neither containing any organic remains. There is not usually any conglomerate or other mark of violent change of physical conditions accompanying this sudden alteration of sediments.

The organic remains of this upper part of the Silurian system are extremely abundant. *Individuals* are very numerous, and species not scarce. This abundance is most conspicuous near the top of the flaggy shales: it dies away rapidly in the brown sandstones, and traces of marine life become nearly or altogether lost *before any red sediments appear*. The red sediments contain no forms of life, except fishes locally; but the cessation of invertebral life began without their influence, being probably extinguished by rapid white sediments, and not permitted to be renewed during the deposition of the red rocks. It is a case of *gradual cessation without renewal*, not of sudden destruction and replacement. In Carmarthenshire, life in the sea was *interrupted* by a mass of red sediments, renewed again in purple and gray beds above, and afterwards finally *extinguished* and followed by red accumulations.

If the white, gray, and brown sandstones were, in consequence of the gradual manner in which the transition happens between them, united to the old red formations, we must by like reasoning be compelled to include with them the whole of the upper flaggy Silurian series, and then the Aymestry limestones would be the boundary. But when this vanishes or is untraceable, we should find no boundary till the Wenlock limestone were reached. Moreover, the Silurian life is continued into these sandstones, but nothing of the peculiar organisms of the Old Red occurs therein, for the plants cannot be justly so termed.

Assuming, then the flaggy shale to be limited between the Aymestry Rock below, and the brown and light coloured sandstones above, its thickness is about 100 or 200 feet. In the lower part it scarcely differs from the Aymestry Rock, being in thick beds full of nodules; the middle part becomes more flaggy, and more micaceous, marked vermicularly, and very rich in small shells and corals, with (rarely and locally) Ichthyodorulites; the upper part, equally fossiliferous, is still more sandy and flaggy (with a few thin irregular limestone nodules), and more strongly marked with littoral effects, and thus passes into the sandstone series.

The colour of these shales is internally bluish gray; but this is seldom perfectly seen except in deep excavations, for the external surfaces are embrowned by a change of the oxidation of the iron. In the large quarry at Halesend, blue and brown sediments alternate in the middle part of the flaggy series.

The surface occupied by the Upper Ludlow shales in the Malvern district is in general very narrow and sinuous, the widest part being between the lines of Aymestry Rock (A) and (B), already described. In the extreme south-west corner of the district, in the triangular area between Dingwood-park Farm and Woodfields, some of these beds probably occur on the eastern side, but it is somewhat doubtful whether they can be traced at all between this point and Ledbury, along the straight boundary of the Silurian region; for in this line of boundary it appears that the Old Red Sandstone is nearly in contact with the Wenlock limestone, though near Ledbury it is just possible to perceive the Aymestry band. North of Ledbury, the Upper Ludlow shales grow distinct, and range with entire continuity on the west side of Dog Hill and Frith Wood (vertical near Ledbury, afterwards dipping steeply to the west), they widen and form a synclinal across the Petty France Road, and another at Hope-end Farm. The long elliptical anticlinal of Raffnal Wood and Wellington Heath is formed of this rock. It skirts with a steep westerly dip (70°) the side of Raycomb Wood, sweeps round by Comb Hill, and Pound, and is traceable by Old Colwall, into the great synclinal between Rilbury and Sitch Wood already noticed. On the northern opening of this great hollow, its boundary against the old red is uneven, and it rises into insulated and peninsular patches, very fossiliferous, south of Colwall and about Cumming's Farm and Barton Court. Its area is rather wide (not a quarter of a mile) on the sloping ground between Chance's Pitch and Old Castle (dip to the north 16°), but much contracted from thence (with beds at first vertical,

gradual from the Aymestry rock to the Ludlow series, and from this through the brown and gray sandstones above (not always present) to the Old Red Sandstone.

The road sections near Dog Hill Turnpike, north of Ledbury, may be first noticed. Here we have, in descending order, from west to east:—

	Feet.
13. Old Red Sandstone, the lower part consisting of red marls with green bands and cornstones, in vertical or highly inclined beds. Near the bottom some thin laminated micaceous sandstone beds.	
12. Brown and gray sandstone	75
11. Upper Ludlow shales, dipping westward 85°, or vertical (or even curled over at the top toward the west), thickness	100
10. Aymestry rock.	

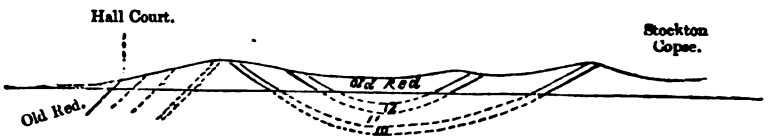
About Frith Farm, the Upper Ludlow rocks yield many fossils, and this character accompanies in a remarkable degree the whole western boundary of the Silurians as far as Comb Hill (dip west), and returns with it by Pound (dip east), Barton Court, and Old Castle, to Evendine. At all these places the passage may be traced from the Ludlow series to the beds above and below. Above Old Castle, the Upper Ludlow flaggy beds, with Cypricardia, and black rotten bands very full of fossils, dip to the north 16°. On the west side of Raycomb Wood, and on the west side of Raffnal Wood, the brown, yellow, and red laminated sandstones are quarried. Brock Hill offers a good general section of the junction of Old Red with the Silurians. Here we have in descending order from west to east, dipping 41° westward,—

	Feet.	In.
13. Old Red Sandstone; the lowest part consisting of red sandy marls		
12. Laminated white and yellow sandstone	0	8
Red sandy marls	0	6
Laminated white and yellow sandstone	3	0
Red sandy marls	0	3
Laminated white and yellow sandstone, with *Lingula minima* .	1	5
Red sandy marls	0	4
Laminated white and yellow sandstone	2	6
Red sandy marls	0	3
Laminated white and yellow sandstone, as above, rather micaceous, with some black carbonaceous plant stains. The total thickness is about	51	0
(Abundance of *Leptæna lata* and other fossils at the junction of Nos. 11 and 12.)		
11. Upper Ludlow, a series of flaggy beds, with wayboards of clay (2 inches thick), and some subcalcareous nodular beds. Cavities left by corals occur in some of the beds. Ripple marks and vermicular surfaces occur. Thickness not exactly ascertainable.		
10. Aymestry nodular beds, with a band of thin-bedded limestone below.		

At Mathon Court in the roadstone quarry, fossils are very plentiful in the Upper Ludlow (including Onchus), and thin flattened nodules of

shelly limestone occur. These beds dip westward 31°, while almost in contact the old red sandstone dips only 18° in the same direction.

Between Hall Court and Stockton Copse, a synclinal section may be traced in the road thus, looking to the north; the same numbers (10 to



13) being used as in the previous pages. The eastward dips are 37½ ±. the westward very moderate 18° and 5°. The beds No. 12 are in this vicinity of uncommon excellence, for flagstone, being regularly bedded, hard, durable, and of good colour. The best quarry is on the westward dip, between Mathon Lodge and Stockton Copse.

A similar succession may be recognised about Overley Farm.

Perhaps the best section in the whole Malvern district is that given by the large quarry at Halesend Farm, which opens the whole of the Aymestry ridge, and has the advantage of showing all the beds, from the Old Red Sandstone to the Lower Ludlow series. The details of this section follow in descending order, the uppermost beds lying on the west. The strata bear the same numbers as in the preceding pages.

Old Red Sandstone and Marls.

Dip westward 65°.

		Thickness in feet.
	Gray and yellowish micaceous sandstones (dip westward 62°) in laminæ, 2 inches thick	35
	(Layer of shale, and a few shells, *Leptæna lata*)	0
12	Gray micaceous sandstones, the surfaces minutely undulated; the laminæ thin	20

[redacted]

		Thickness in feet.
10 Passage beds.	Series of thick solid nodular calcareous beds, with many corals on the upper faces; shale partings between the beds. (True Aymestry Rock.)	22
	Shale, with but few calcareous nodules	12
	Series of shales alternating with solid limestone in flattened nodules, or thin bands 1 to 2 inches thick, the shale being in quantity equal to double of, or quadruple of, the limestone	41
9	Series of the Lower Ludlow shales, with distant lines of argillaceous nodules	

In this section there is some difficulty in choosing a line of boundary between Nos. 11 and 12; for they gradually assume common characters and do not admit of a hard line of separation. No. 12 here clearly belongs to the Silurian series. In like manner the distinction of No. 11 and No. 10 is somewhat arbitrary, and it may be thought more natural to refer all the upper noduliferous beds to the Aymestry rock, as well as all the lower beds with flattened nodules, which would give it a very unusual total thickness (118 feet). Similar facts may be verified about Barry's Gate, Barrow Mill, and Longley Green. Upon the whole, these may be regarded as *passage-beds*, naturally to be associated with the limestone, if their calcareous element predominates, with the shales when it diminishes or fails.

12. DOWNTON SANDSTONE.

Brown, yellowish, gray, or white laminated sandstone (thickness 10 to 100 feet).

The grains which enter into the composition of these sandstones are almost entirely quartz. Mica is not plentiful in them, except sometimes on the surfaces of parting. The beds are thin, and sometimes firm and united enough to make good flags or building-stone, (near Hall's Court in particular). In the lower portion, a few organic remains (of the Silurian types) occur, but in the upper portion, nothing but black specks and patches of a carbonaceous substance, and some traces of fucoids.

These beds have in some respects and in several places a certain resemblance to the laminated Caradoc sandstone, not sufficient to render the identification and distinction of each at all doubtful, but enough to shew that the argillo-calcareous Wenlock and Ludlow deposits, with their peculiar suites of organic remains, were produced in the sea, during the prevalence of one characteristic sequence of physical conditions, interposed as to time between two examples of a very different set of conditions, viz., those which accompanied the Caradoc sandstones, and those which accompanied the Downton sandstones. It is not then to

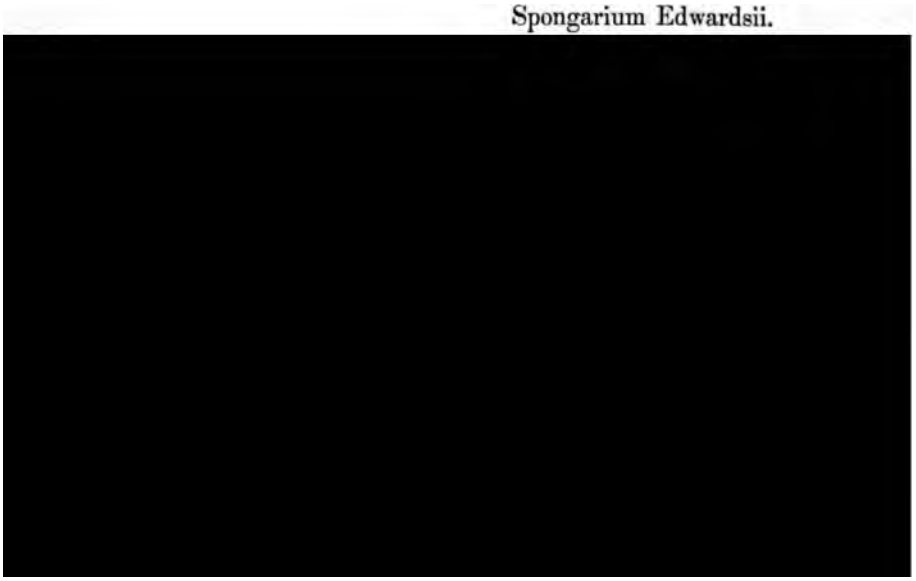
be wondered at that they contain a peculiar and appropriate suite of organic remains.

These laminated sandstones form the passage from the protoxidated Ludlow shales and sandstones to the peroxidated shales and sandstones of the old red series. They can generally be in some degree traced at most points where the sections are tolerably clear. They are quarried at the west side of Raycomb Wood and Raffnal Wood, and again in the fields north of Mathon Court, and at Brock Hill, and make excellent flagstone. The best general sections are those of Brock Hill quarries already given at p. 97, and Hall Court, and there is no doubt on comparing them with the series of beds at Halesend Farm, p. 98 that the brownish and yellowish beds there (if not some of the upper gray sandy shales with Orthoceras and other fossils) belong to this group It stands therefore as a group of *passage beds*, the lower part really allied to Silurian, and the upper part really allied to the old red strata-fications. With these passage-beds the long Silurian series terminates in the Malvern region.

Here also ends the Silurian life, at least in this district, and by comparing the following list of species of animal remains which are common or at least not unfrequent in the Upper Ludlow rocks, with that already given for the lowest Caradoc fossils, p. 61, and the list of Wenlock fossils, p. 88, the great amount of organic change in the course of the Silurian period may be estimated, and the mind be prepared for the further investigation of the subject to which a future section of this memoir is devoted. There is but one species (*Cornulites serpularius*) which occurs in all the beds.

Asterisks are placed against those which appear in the Wenlock list.

POLYPIARIA	Favosites ramulosa.
	Alveolites fibrosa.
	Spongarium Edwardsii.



CONCHIFERA, MESOMYONA.	*Avicula lineata.
	*——— retroflexa.
	——— rectangularis.
PLAGIMYONA.	Cypricardia cymbæformis.
	——— amygdalina.
	——— retusa.
	——— impressa.
	Orthonota rigida.
	Nucula antiqua.
	——— Cawdori.
	——— ovalis.
	——— lævis.
GASTEROPODA . . .	Pleurotomaria Lloydii
	Murchisonia corallii.
	——— articulata.
	Turritella obsoleta.
	Turbo corallii.
	——— carinatus.
	Euomphalus carinatus.
	*——— funatus.
	Loxonema fusiformis.
PTEROPODA	*Conularia Sowerbii
HETEROPODA	Bellerophon expansus.
	——— Urii.
CEPHALOPODA . . .	Orthoceras Ludense.
	——— Mocktreense.
	——— bullatum.
	——— ibex.
	——— articulatum.
	——— virgatum.
	——— canaliculatum, & others.
	Gomphoceras pyriforme.
	Lituites articulatus.
CRUSTACEA	*Dalmania caudata.
	*Calymene Blumenbachii.
	Homalonotus Knightii.
ANNELIDA	Serpulites longissimus
	*Cornulites serpularius.
	Tentaculites tenuis.
	Trachyderma squamosa, n. s.
FISHES	Onchus Murchisoni.
	——— tenuistriatus.

13, 14, 15.—OLD RED SYSTEM.

(Thickness, at a maximum, 8000 feet.)

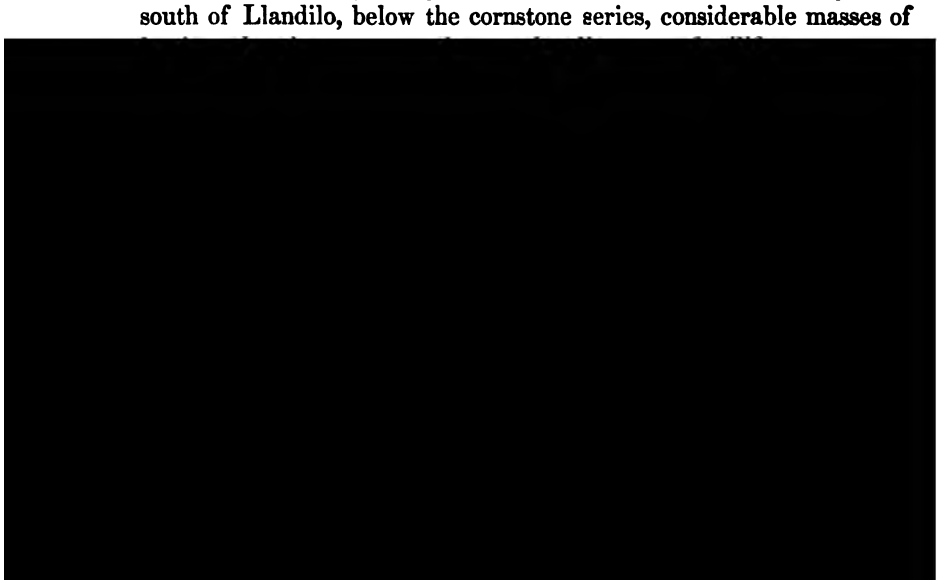
The Old Red system of strata, if we collect information concerning it from the whole region west of the Severn, appears to consist of the following principal parts:—

15. LOWER PART.—Thick red laminated marls and shales, variegated with greenish bands and blotches, and beds and lumps of cornstone; and including many thin beds of laminated sandstone, some of which are at the bottom. This group of strata is continuous on the west side of the Abberley, Malvern, and May Hill districts: it surrounds the districts of Woolhope and Usk.

14. MIDDLE PART.—Thick laminated red sandstones with thinner sandy red marls (a few greenish bands), and traces of cornstones. This series forms the hills about Michel Dean, Ross, Monmouth, and Abergavenny, but grows thinner as we proceed westward into Pembrokeshire.

13. UPPER PART.—Conglomerates with thin red marls and sandstones. These appear round the edge of the Forest of Dean and on the north side of the great coal field of South Wales. The Kymin, Trelech Beacon, and the Vans of Brecon show these rocks, which also are traceable in Caldy Island, &c.

(In South Wales, especially between Trecastle and Llandovery, and south of Llandilo, below the cornstone series, considerable masses of



some green marly bands, and layers of nodules of cornstone. A similar succession of sandstones with much marl and more considerable beds of cornstone, not amounting altogether to above 2500 feet, is all that can be seen of the Old Red deposits in the district of Malvern and Ledbury. No organic remains have been found in them. The cornstone and imperfect limestone shew, when examined by the microscope, no trace of organization, and this singular *absence* of the traces of life, coincident with the prevalence of peroxide of iron, is the more instructive when contrasted with the *richness* in organisms of the protoxidated Silurian sediments below, and of the similarly coloured carboniferous rocks above. The cornstones of Malvern and Wall Hills might, perhaps, yield fish bones if more thoroughly searched.

The Old Red Sandstone is everywhere in contact with the Downton beds or with the ordinary Upper Ludlow shales, on the western side of the Malvern district, from the north side of Hadfield Camp Hill by Ledbury, Frith Farm, Comb Hill, Cumming's Farm, Old Castle, Brockhill, Malvern Lodge, Ham Green, Overley, Hales-end Farm, Barrow Mill, Langley Green, the western slope of the Suckley Hills, and Lord's Wood. It spreads from this line westward to Bromyard, Leominster, Hereford, and Ross, into one broad area broken only by the long Silurian elevation of Woolhope Forest. From Hadfield Camp Hill, southward, its eastern outline is irregular, but does not greatly vary from a general direction to the S. S. W., as far as Kilcot Green, west of Newent, a distance of six miles. In this range it is generally in contact with New Red Sandstones or conglomerates, as may be seen at Brooms Green, Callow Farm, Castle Farm, and many other places; but at a certain number of points there is interposed between the red strata of such extremely different ages, a thin interrupted outcrop of coal with blue shales and some sandstones. These occurrences have been noted in the course of the Survey seven times between the Malvern Hills and May Hill; it will be seen hereafter that they have been noticed four times in the Abberley range of hills under circumstances considerably similar. If we recollect that these occurrences of coal are along the great line of unconformed stratification alluded to in the introductory view (p. 5), and that coal is worked both to the south in Kingswood, and to the north in the Clee Hills, and along the Severn, we shall perceive the importance of the question which these facts suggest: viz., whether broad, if not continuous coal-fields exist beneath the Vale of the Severn, between Gloucester and Bewdley. For some facts bearing on this subject the following pages may be consulted.

CARBONIFEROUS DEPOSITS.

16.
17. } CARBONIFEROUS LIMESTONE. MILLSTONE GRIT.
18.

These are totally absent from the district of Malvern.

19. COAL MEASURES.

As already stated, these may be seen at seven points between May Hill and the southern part of the Malvern district, in a narrow area between the Old and the New Red Sandstone, and at several of these points coal has been worked. Murchison has already described the line of outcrop, and discussed the geological bearing of the phenomena which he observed.* By far the largest areas and the most extensive works are in the vicinity of Newent, at Bowlsden and Hill-house, the former two miles to the south-west, the latter as far to the west of Newent. A little north of Hill-house, the coal shales appear near Whitehouse; again in the road near Oxenhall Court; again on the road between Great Pella and Hill-end; again crossing the turnpike-road, near Castle Tump; and at Pitleases west of Ryelass. In all these places certain facts are observed; the coal outcrop is narrow, it lies between the Old Red and the New Red; its accompanying beds are mostly shales; the Old Red Sandstone which appears below the coal is *not the upper part of the red* deposit; it is usually a sandy and laminated rock often dipping rapidly eastward, while the New Red is horizontal or but moderately inclined in the same direction. The New Red beds are either thick conglomerates or soft, often pebbly, sandstones. Commencing our examination at Bowlsden near Newent, we find abun-

		Thickness. Fath.	Yds.	Ft.	In.
	1. Gravel	2	1	0	0
	2. Marl	1	0	0	0
	3. Red and white rock	3	1	0	0
	4. Duns, &c.	8	0	0	0
I. and II.	Coal, *in four beds*	1	0	0	0
	5. Duns, &c.	4	0	1	6
III.	Coal	0	1	0	4
	Strata	19	0	1	6
	Coals	1	1	0	4
		20	1	1	10

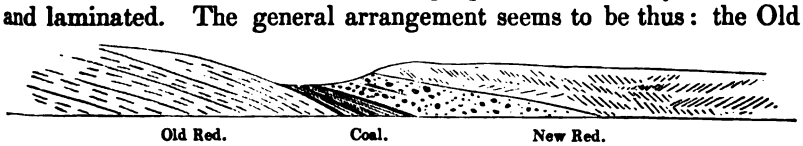
In this account the three upper beds are parts of the New Red Conglomerate, with its included marls; the Duns are the dark shales which seem to prevail in connection with the coal beds,* and include some light-coloured sandstone.

Sir R. I. Murchison has given a section of these beds at Lower-house, west of Newent, which passed through—

		Ft.
	New red sandstone	21
	Whitish clay Hard whitish sandstone, with plants Reddish-brown clunch shale, &c.	100
I. and II.	Coal	7
III.	Shale and three beds of Coal (2 ft., 1 ft. 6 in., and 1 ft. 2 in.), the lowest being sulphureous	16

He also mentions the quadripartite character of the great *coal bed at Bowlsden.*†

Proceeding a mile to the north-west, we find a narrower exposure of coal measures, the continuation of the same beds, and learn that at intervals for the last 40 years pits have been sunk and borings made in various situations between Hill-house and White-house to depths from 20 to 100 and it is said even 200 yards. The beds above are here red and purple sandstone, and magnesian conglomerate (Hill-house), and the beds associated with the coal are chiefly dark-coloured shales. A white sandstone rock was found in a well at a cottage north of Kilcot Green. The beds of Old Red Sandstone seen below the coal measures or below the New Red are of a purple tint, often very micaceous and laminated. The general arrangement seems to be thus: the Old



Red beds, dipping rapidly eastward; these covered by the coal; and the

* Memoirs of W. Smith, LL.D., p. 58.

† Silurian System, p. 153.

New Red resting (with less inclination, but not otherwise unconformably) on both. In an exposure of micaceous Old Red Sandstone west of Hill-house, the beds strike E. and W., and dip south 23°; the New Red dips gently to the east, except at White-house where its conglomeritic beds dip 20° to the S. E., though in the neighbouring brook on the line of this dip, its red and yellow layers are nearly level. Some coal was found about the year 1800 in a pit sunk about 20 yards deep, S. W. of White-house, and distant from it 150 yards. The very narrow coal measure outcrop, in the road west of White-house, is between micaceous Old Red Sandstone and New Red conglomerate. According to information which we obtained by inquiry on the spot, in 1842, there were found at Hill-house three beds of coal, in the following order, viz.:—

I. and II.	Big Coal	5 ft. to 7 ft. thick.
	Shale	1 ft. „ 1 ft. „
	Little Coal	1 ft. „ ½ in. „
	Shale	8 ft. or 9 ft. „
III.	Coal, in three parts	5 ft. „

This agrees sufficiently with the section given (on similar authority) by Mr. Maclauchlan,* as under—

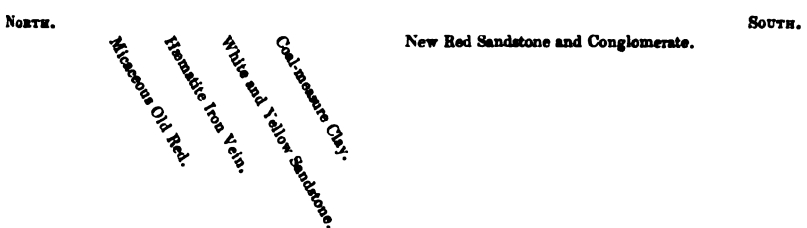
	Red clay	90 feet thick.
	Sand rock	4 „
	Clod, or clay	8 „
I.	Coal	7 „
	Clod	4 „
II.	Coal	2½ „
	Clod	15 „
III.	Coal	4 „
	Clod.	

The upper bed was that principally worked. It was very sulphureous.

On combining the various sections which have been given, it is apparent that the same beds occur in each situation, and they are accordingly numbered to correspond; the big coal, which is the best, being the upper

The red sandstone on the western side of the little valley strikes N. 10° W., and dips to the eastward 20°. The beds are red sandy marls with whitish spots and whitish stains along the joints, and gray and reddish laminated sandstones. On the east of the stream, brown and gray and reddish laminated sandstones, mostly micaceous, strike N. 38° E., and dip south-eastward at first 30°, then 40°, then 70°. These are succeeded by similarly inclined overlying clays with a "coal smut;" and over this comes the New Red Series, the lowest part being conglomerate (containing pebbles of Old Red Sandstone), and dipping eastward from 10° to 15°, while the upper part is a soft friable sandstone with nearly level stratification.

Along the line of junction of the Old and the New Red deposits, N.E. of Pella, red oxide of iron has been dug in a line directed N. 35° E. Coal was dug here, and its smut is visible with clay at Hill-end, while on the western side is Old Red marl with traces of cornstone. A thin coal was found in the tunnel for the Newent canal. From Castle Farm to the turnpike-road, the Old Red beds turn eastward and dip southward 14° against the New Red Sandstone, scarcely disclosing the coal. In the turnpike-road, a very interesting section appears at Castle Tump, showing the passage from the Old to the New Red, as under.



Coal was formerly dug at Pitleases, between Old Sheals and Ryelass, on a line of outcrop which may be traced (to the N.N.E.) for above half a mile, between micaceous old red sandstone (dipping eastward 20°) and new red sandstone, stained black or yellow where in contact with the coal shale.

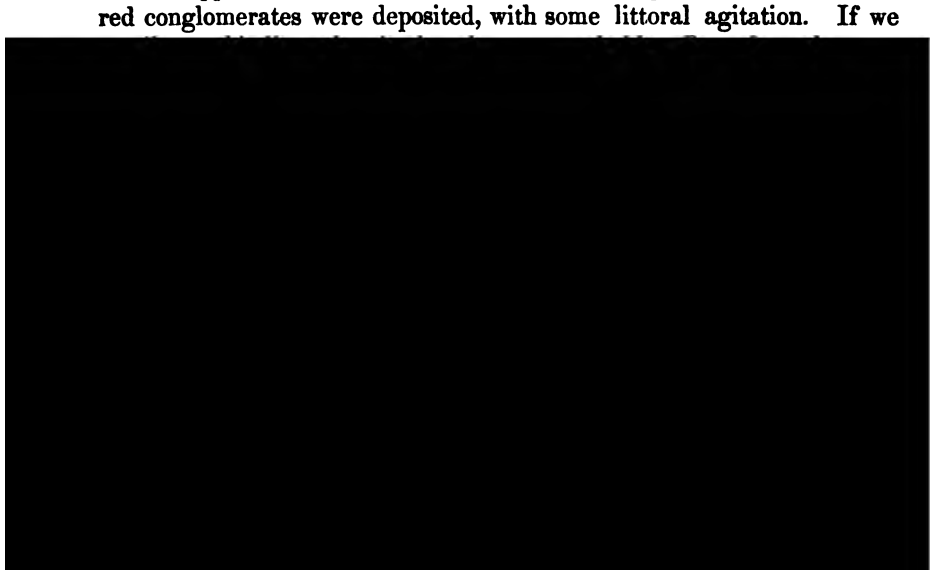
The outcrop of coal was not actually seen farther to the north in the course of the survey than east of Gamage Hall, the point to which Sir R. Murchison traced it; yet it may be presumed to exist, and to have been formerly visible, since during a survey of this district executed 40 years ago by Dr. Wm. Smith, he found traces of coal about Callow Farm, and shales presumed to be of the carboniferous group still farther to the north.* Adjoining Callow Farm is a large quarry of new red sandstone with some trace of conglomerate. Near the house called Hill, the old red is laminated and micaceous, and dips to the E.N.E.

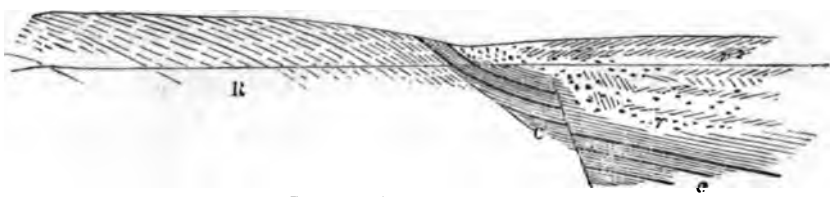
* From unpublished MS. of Wm. Smith, LL.D.

20°. At Broomsgreen the road shews a section from the old (R) to the new red (*r*): the former consisting of red and greenish marls, and red and

light-coloured sandstones in some confusion, and mostly *dipping westward* (33°), or from the new red sandstone which is here without conglomerate. On the western side of Haffield Hill the old red *dips westerly*, being in that direction covered by *higher beds* of the old red series.

From these two last cases, it would appear that the general *westerly dip* of the Ledbury Hills is continued to, and passes under the area now covered by the new red sandstone, so as to make with the *westward rise* which is observed at most points from Hill-house to Kilcot Green, a subterranean synclinal of old red, quite similar to that which occupies the surface between Ledbury and the Woolhope Hills. It is only on the western side of this synclinal that we have as yet seen the outcrop of coal, which has been thus traced at frequent recurring points on a line about four miles in length. Along this line the strata are only so far disturbed, as in a few places to assume quickly increasing dips, and to bend down somewhat abruptly. Whether the coal follows these curvatures *exactly* cannot be clearly ascertained; but from what is *seen* on the Oxenhall road, from what is to be *inferred* from the old workings, or collected from the traditional knowledge of the neighbourhood, *we may believe that it does*, at least *approximately*. These flexures of the old red and coal strata were anterior to the age of the new red, which lies unconformably in reference to them; these strata so bent appear to have constituted a sea-shore against which the new red conglomerates were deposited, with some littoral agitation. If we





R. Old red sandstone.
C. Coal measures.
r. New red conglomerate.
r^2. New red sandstone.

Though, as we have before admitted, the coal is at least approximately bent in the same general curvatures as the old red in which it rests, it seems probable that it is not strictly and exactly conformable to that rock; for it appears neither to rest on one certain portion of that rock, nor on portions which belong exclusively to the upper divisions of it. Hence we may probably conclude that previous to the deposition of these coal beds upon the old red, that rock had undergone displacement, and had been elevated from the level at which it was first deposited.

MESOZOIC STRATA OF THE MALVERN DISTRICT.

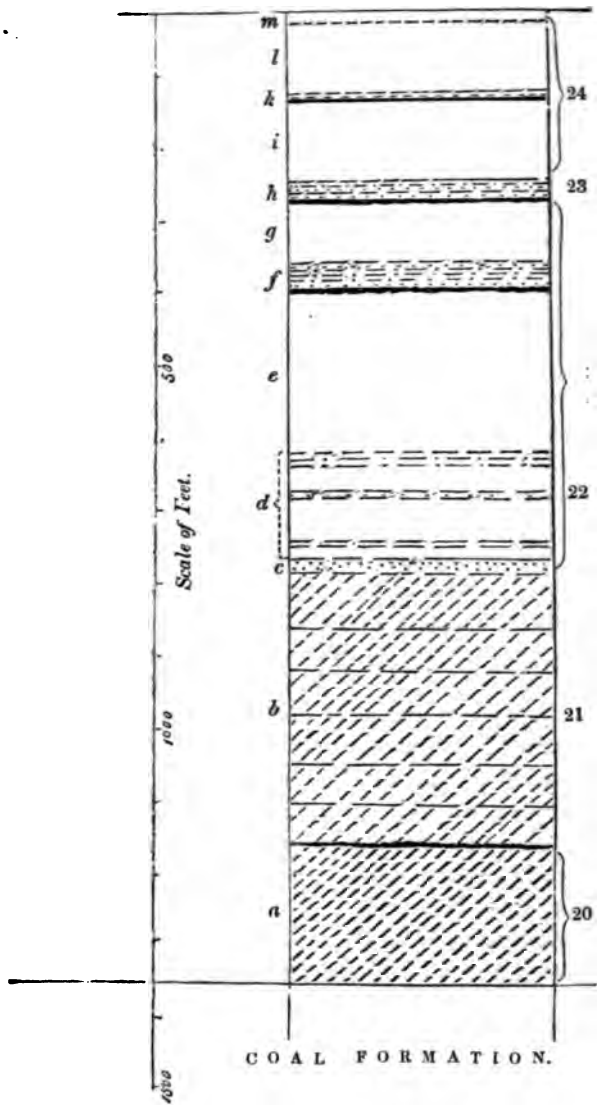
20 to 24.—NEW RED SYSTEM.

In this mass of strata, as exhibited in the region of Malvern and the Severn, the following several orders of sediment occur. Red argillaceous sediment, which is beyond comparison most abundant, most extensive and most characteristic. It is hardly micaceous, not properly shaly, but rather lumpy and marly and without fossils. Gray or green argillaceous sediments of the same quality as the red, except as to colour, that having peroxide but this protoxide of iron. Pale bluish laminated shales, rather than marls, in fact argillaceous beds much like some liassic shales. Red and white sandy beds, partly micaceous, seldom firm enough for building. The white sandstone is occasionally concretionary. Red sandstone, rendered conglomeritic by admixture of quartz, brown sandstone, and other sorts of stone all rolled to pebbles. A peculiar and local conglomerate, the basis red clay or sand, with fragments of the neighbouring rocks, abundantly imbedded. White, gray, and brownish sandstones, which lie in particular bands in the deposits, or are very sparingly mixed with the spottings of gray marls in the midst of the red marls. These are almost exclusively fine-grained and in thin beds, but where they are thickest, as about Langdon, Burgh Hill, and Pendock, they become in part coarse and even conglomeritic, and yield organic remains.

As to the order of occurrence of these beds we see (as in the Section on p. 111) the great masses of peculiar conglomerates at the bottom (*a*), surmounted by the red sandstones with ordinary conglomerates (*b*), while the upper parts of the system consist of marls (*e*, *g*, *i*, *l*, *m*), enclosing various sandstones (*c*, *d*, *f*, *h*, *k*). We may regard the fossiliferous parts of these as analogous to the sandy bone bed of the

ORDINARY LIAS.

Bone Beds and Shales.



20. HAFFIELD CONGLOMERATE.

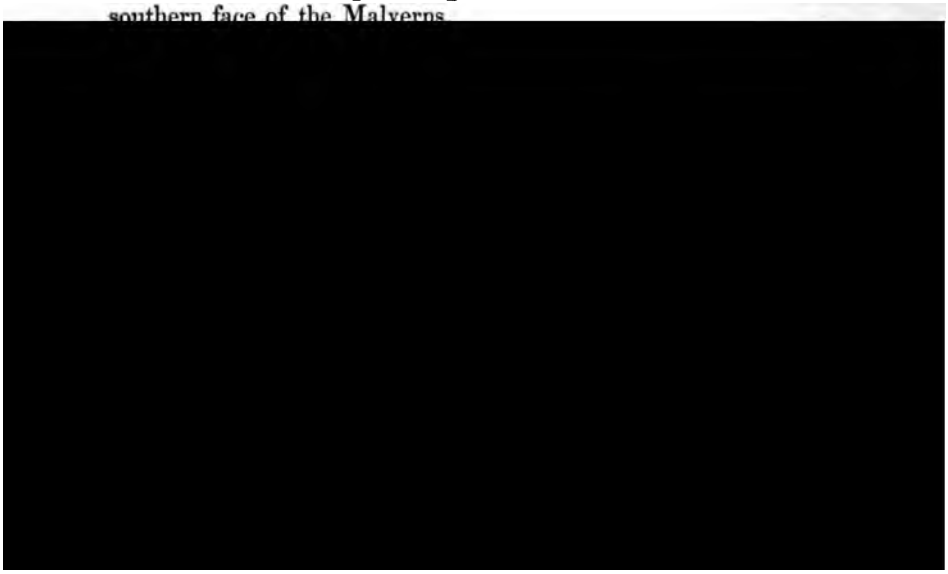
(Thickness, 0 to 200 feet.)

The lowest member of the New Red series in the Malvern district, is generally coherent, and sometimes cemented together by smaller portions, and fine, red sedimentary matter, into pretty firm rock. The

pebbles and fragments are such as the adjacent stratified and igneous rocks of the Malvern Hills might afford: they lie accumulated against these rocks, and clearly bespeak local and limited, but violent, sea movements against the elevated Malvern Hills, not elevated, however, to their present height above the sea. These conglomerates, usually of a dark red or purplish tint, nowhere rise to more than 450 feet above the sea (Haffield Camp is, perhaps, of about this height, and Rosemary Hill, near Knightsford Bridge, under 400), and seldom to above 300 feet; nor is there reason to admit that at any earlier geological epoch they can have extended up the slopes of the Silurian strata to a greater height than about 600 feet. On these strata, along all the southern edge of the Malvern district, they rest unconformably, and occupy a breadth usually less than a quarter of a mile, except in the hill crowned by the Old Camp, at Haffield, where they are somewhat wider.

The range of the rock from Haffield to Haye's Copse is under three miles; and in this short range it touches old red sandstone east of Donnington, Upper Ludlow rock near Woodfield, Wenlock limestone at Clincher's Mill, Woolhope limestone N.W. of Toney's Farm, and Caradoc sandstone along the south slope of Howler's Heath. It just reaches the Malvern syenite of Keys-end Hill. Along all its course the adjacent rocks, for a certain breadth from its edge, are tinged red, a circumstance which may with confidence be ascribed to its former greater extension. It usually dips a little to the southward.

Following the eastern side of the Malvern Hills, we find abundance of the new red deposits, but nowhere the slightest trace of this peculiar member of it, until we pass the very extremity of the chain and reach the little ridge of syenite which is cut through in Cowley Park. The red pebbly deposit, which here rests in a hollow of the syenite, appears to belong to this conglomerate; the pebbles in it offer a peculiar shining surface, which is recognised again in the more extended masses on the southern face of the Malverns.



Wenlock shales, which dip eastward. The conglomeritic mass has a very trappean aspect, because it contains many trap fragments—a circumstance common to it in other situations. The section (p. 76), from west to east, will explain the relative position of the masses.

These beds appear again in connection with the red sandstone in the steep road from Bridges' Stone to Patches' Farm. They are here more nearly horizontal.

Beyond Alfrick the Haffield conglomerate nowhere shows itself, till we arrive at the next great valley, and reach the very base of the New Red system in the only place where it is exposed, viz., in the woody hill, S.E. of Knightsford Bridge, and in the road-cutting which there leads from Bates' Bush to the valley of the Teme. Along this line of road an excellent section is made, which on the west shows the Haffield conglomerate; above this a great thickness of new red sandstone, with its usual complication of variously-inclined laminæ, and on the eastern side red and green marls with thin sandstones. The conglomerate dips to the south-east (13°); the laminæ of the sandstone also are inclined in that direction (from 5° to 28°); the superincumbent marls and thin sandstones are greatly disturbed, in places vertical, bent, arched, and broken by faults. This excellent section shows the true relations of these three members of the New Red system, and furnishes the clue to many other less complete exhibitions of the beds.

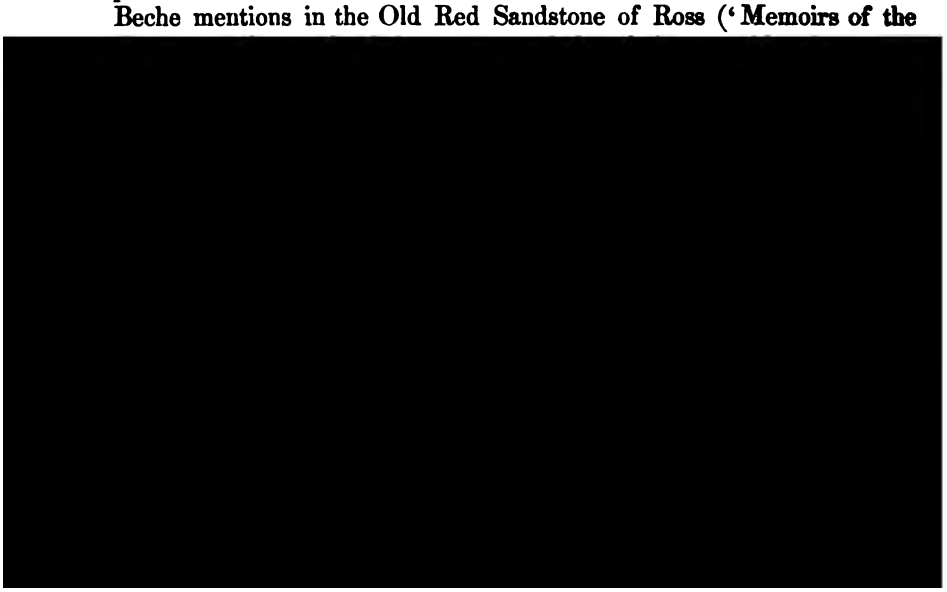
Combining the observations which have now been mentioned, touching the Haffield conglomerate, it appears that the accumulation of the pebbly components of this rock is, if not confined to the localities or districts which have been named, at least nowhere else apparent at the surface. It is worthy of remark, that these points are all in situations which were or may be believed to have been bays or sheltered parts of the ancient sea-coast line; that the constituent fragments which abound in the conglomerate are very rarely rolled to spheroidal masses, and often only blunted at the angles; and that the two most conspicuous masses, viz., that south of the Malverns, and that of the Teme Valley, decline rapidly toward the south. May we not conclude from these facts, that the main set of the sea currents against the Malvern Hills, in the earliest Red Sandstone period, was from north to south; that the materials derived from the waste of the adjoining lands were drifted southwards to places of rest, such as bays and the depressions of valleys might yield, while the exposed coast of the Malvern ridge, which was raked by the current, and offered no sheltering hollows, is in a great degree deprived of these deposits? We shall find the same question suggested by phenomena equally striking in another district, to be noticed hereafter. (*See* Memoirs of the Geo. Survey, vol. i. p. 11 *et seq.*)

21. NEWENT SANDSTONE AND CONGLOMERATE.

(Thickness, 200 to 400 feet.)

This thick group of arenaceous beds is nowhere so well seen as in the interval between Malvern and May Hill, where it occupies a breadth of above two miles, and is covered by light soil adapted for drill husbandry. In this space is the district called "The Rye-lands." The beds may be very well seen on the road from Malvern, by Redmarley, to Newent. They consist mainly of red sandstone, of unequal degrees of hardness, often very soft, mixed with some conglomerate beds, the pebbles mostly of quartz, small and rounded, and red, laminated sandy shales, rather than marls. These latter beds are thin, and serve as partings in the red sandstones, occurring, however, in some places at frequent intervals, and giving thereby to the section the appearance of alternating sandstones and shales. The lamination of these shale beds is parallel, or nearly so, to the general mass, or bounding surfaces of each, and separate beds have usually at least an approximate parallelism; and they afford the best, though not always unobjectionable, indications of the true dip of the stratification.

No reliance, as to the dip of the strata, can be placed on the lamination of the red sandstones, especially if these exist in great thickness, for the varieties of false bedding and oblique lamination in the beds are almost innumerable, and it is only after a very extensive survey that anything like a general rule, connecting them with the true dip, arises. Upon the whole, there appears frequently, if not generally, a tendency to *the same direction* in the true dip of the beds and the inclination of the laminæ, but there is no conformity in the *angle of slope*, and the whole rock seems to be in several instances divisible into elongated, subparallel masses, with a lenticular cross section, such as Sir H. T. De la Beche mentions in the Old Red Sandstone of Ross ('Memoirs of the



as only the very uppermost layers of this series, if they should not rather be ranked with the next, occur in the road. The same beds appeared in the cutting at Great Malvern, at the point where the road branches off to the Wych, (see p. 116). At a point mentioned by Sir R. I. Murchison, a little to the N.W. of Great Malvern Church, in an excavation above the road, red and white sands appear in confusion. At a point near North End, in the great quarry of syenite, the red sand was cut through, under a load of detritus which had fallen down the hill, and in the hollow north of Whippet's it is seen, with laminæ dipping 45° to the northward. It shows distinctly again at Long Copse, west of Upper Sandlin, in the Old Lane (white sandstone), at Bridges Stone, on Leigh Brook, and from thence, by Alfrick, to Grimsend House, west of Ravenhills Green, and the road-cutting west of Bates' Bush. The sandstone quarry in this last situation is of some importance in building.

22. NEW RED MARL (lower group).

(Thickness, 400 to 500 feet.)

It has been already observed that the sandstone series (No. 21) exhibits in its upper part some white beds (*c*) of sandstone, and then red marls in many parts of the mass. The thick red marl which rests upon that sandstone contains also in its lower part some white and red sandstone, in thin beds (*d*). The exact boundary line between them is thus softened, without being obliterated. Much higher in these red marls occur some other thin light-coloured arenaceous beds and whitish marls (*f*), which may be regarded as indicating the process of change to those thicker fossiliferous sandstones and blue shaly clays which Sir R. I. Murchison and Mr. Strickland have called Keüper (*h*).

The thick marly series, thus characterized, passes from a narrow line of contact with the rocks of May Hill, north-eastward, to occupy a wide triangular space between Huntley, Hartpury, and Newent. Hence they continue to the northward in a broad area, which, however, grows continually narrower till it contracts to a very small breadth at Perrin's Court Farm, in contact with the syenite. It is confined to this narrow course against the Keysend, Raggedstone, and Midsummer Hills, being in fact almost covered up by the Keüper sandstones, which nearly touch the syenite (see the coloured map). From Castle Merton, northward, it expands again very much, and stretches from the foot of the Malvern Hills to the Severn. From Great Malvern to the Teme, below Knightsford Bridge, this red marl is seldom far removed from the Silurian hills, and in some places where the red sandstone is absent or covered up, touches their boundary. It spreads eastward to and beyond the Severn. There are two irregularly-shaped areas of these marls (surrounded by low hills of Keüper).

to the north-east we reach the vicinity of Bulley. Here and at Tibberton a singularly-shaped exhibition of it has been traced, and the line proceeds by Barber's Bridge, east of Hartpury, round Catsbury Hill, round Limburg Hill, and from thence northward to a farm west of Horridge Street, where it is quarried. From this point the line continues in a distinct ridge on the left bank of the Glynch (with one small outlier on the right bank), by Staunton Coppice and the Parsonage to Dobs Hill, and then turning eastward to Cromer Farm, and again southward to Burg Hill, dips to a synclinal at Gatfield Elm (σ^1) and rises to an anticlinal, marked by the ancient camp of Gadbury* Banks (α^1). On the eastern side of Gadbury, the sandstone occurs in a corresponding ridge, and dips eastwards at Eldersfield, and the Hill Farms. Another synclinal follows (σ^2) in which Birth Hill is placed, followed by a second anticlinal (α^2) the centre of which is Ouse Farm, and its southern point Drinkers Street.

The section from east to west appears thus :—

The Birth Hill synclinal is continuous northwards, between Marsh Court and the Hill Farms to a large expanded synclinal basin surrounded by Keüper and marked in the middle by a conspicuous hill of Lias (Berrow Wood). Sweeping round this hill, at a distance of from half a mile to one mile and a half, and dipping towards it 5° and 7°, the Keüper beds range from near Cromer Green by Pendock Portway (on the line of an ancient road from Gloucester by Gadbury Banks, toward the Camp on Midsummer Hill), Cockshute, Hill End, and Hill Farm, Moor Court, and Pendock Farm, toward Marsh Court, thence by Pigeon House, and Lime Street, to Drinker's End, in a south-

syenitic rocks, while only half a mile to the north the Caradoc sandstones appear in lower ground and are in contact with lower beds of the new red series. From these facts it is evident that the Keüper and new red series generally have been deposited unconformably against the Malvern Palæozoic range, and some basis is afforded for reasoning on the probable former extension of the Lias and oolite over the vale of the Severn.

The natural sections of most interest along this line of outcrop may now be briefly referred to, commencing, as before, in the south.

At Newnham, a complete section of the beds resting on red and variegated marls, is presented under the church, which may be thus represented and described.

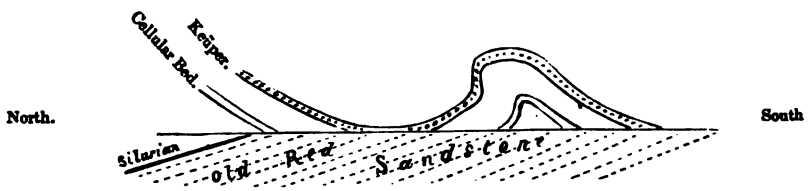
	Thickness in feet.
h Strong bands of yellowish sandstone and red marls	5
g Strong bands of light-coloured sandstone, prominent in the cliff	1
f Thin sandstone bands with thin red and greenish marls	1½
e Red and greenish marls with some soft white bands	4
d Irregularly laminated red marls	4
c Pale greenish band	0½
b Irregularly laminated red marls	12
a White friable undulated band	0½
	28

These beds successively dip to the level of the Severn, (striking N.N.W. and dipping E.N.E.), and are covered up by variegated marls, seen in the cliffs at Broad Oak. On their surfaces we perceive the edges of oblique lamination; long joints ranging north 25° to 30° west; and septariate structures in which a central angular or round area is red, (peroxidated iron), within a zone of bluish or greenish, (protoxidated iron); the whole being contained within a polygonal pattern of white or a very light tint. Fish scales and bones occur in the upper laminated sandstone beds, especially where small pebbles lie on the surfaces of the stone.

Below these beds is a series of variegated marls, with a white band and a little gypsum, and this covers a series of gray and yellowish cellular thin-bedded stone, sometimes reminding us of some of the least pebbly varieties of what has been called magnesian conglomerate, and in other cases like the beds of King's Green. The way in which these beds meet the Old Red sandstones along a line west of Newnham, will be understood by referring to the accompanying diagram.

Old Red. New Red.

North of Newnham, about two miles and a half, is an interesting junction of the Palæozoic and Mesozoic strata, on the line of road from Flaxley to Westbury-on-Severn, as shewn in the following plan.



At Blaisden, the lower cellular, partly magnesian beds (of King's Green), are unconformably in contact with the Woolhope limestone, while to the S.E., about half a mile, is the outcrop of the fossiliferous Keüper. (The ground hereabout is so much covered by drift from the rocks of May Hill, as to leave only a small part of the range of Keüper visible.) The same relative position of the fossiliferous sandstones and the whitish cellular beds below appears at Tibberton.

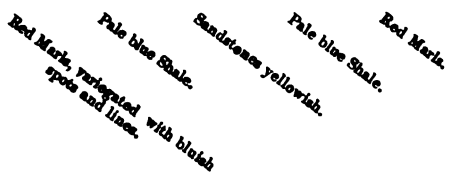
On the road from Upleadon to Horridge Street, near the large farm, south of Glynch Brook, the Keüper sandstones are much quarried, and yield many teeth, bones, and scales of different species of fishes. The section appears thus:—

	Ft.	In.
Red and blue marls, in six or seven bands	4	0
Coarse-grained sandstone	0	6
Blue shale	0	4
Red shale	0	4
Coarse-grained sandstone	0	6
Blue shale, 0 to 1 foot	0	6
Obliquely laminated sandstone	2	1
Blue clay	0	3
Obliquely-laminated sandstone	1	6
Blue shales	2	0

[redacted]

The quarry is extensive; the stone is wrought advantageously into various forms, and appears to be durable.

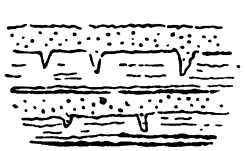
At Eldersfield the road-cutting shows these sandstones, economically of little value, though the church built of them is in good preservation, but in a very clear section as under.



These beds dip to the N.E. 8° or 10°.

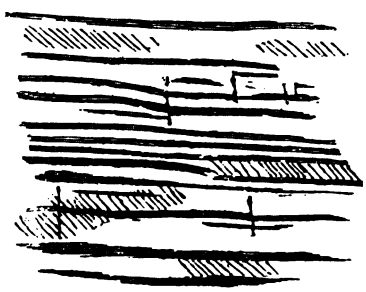
About Pendock Portway, Cockshute, Hill End, Hill Farm, Moor Court and Pendock, the occurrence of blue shale with the white or brown fossiliferous sandstone is very marked. Frequently they alternate, as about Hill End; generally blue shale covers and commonly lies beneath the sandstones. Below the whole is a remarkably mottled and undulated red marl, locally gypsiferous (Red House), and a series of thin whitish beds corresponding perhaps to the more distinctly developed beds of King's Green. Near Moor Court, on the branch road to Red House, is a very interesting quarry, containing characteristic fossils, and exhibiting most of the peculiar mineral qualities of the rock. The beds dip to the S.W. 5°. They are exposed to a depth of 12 feet. In the upper part are blue shales, a little undulated in the stratification. Then thin beds of coarse even conglomeritic sandstone alternating with blue shale succeed: and the base of the whole is a series of thicker sandstones, with thinner bands of the same shale. This conglomeritic sandstone occurs more or less in every exhibition of Keüper; it contains besides the quartz sand many small fragments; white subcalcareous lumps, black specks of *coal*, bits of red jasper, &c. The coal specks lie often on the upper surfaces of the beds. In this conglomerate occur most of the fossils, as radial bones, scales, and teeth of fish; fragments of plants, with elliptical stems, with an external coating of coal (as happens in the coal sandstones), surrounding a furrowed axis of stone.

The conglomeritic bands frequently exhibit in the section *on the under side*, projecting ridges, which enter and fit into depressions of the sandstones on shales below; as thus,



The blue shales resemble those of the Lias, and like them contain nodules, and imperfect septaria; and in these nodules many bivalve shells, and a few fine-leaved plants occur.

In all the quarries of Keüper in this neighbourhood, oblique lamination abounds in the sandstones, and marks the peculiar manner of their deposition, under the influence of limited and variable currents and shallow water. The subjoined sketch may illustrate this circumstance the dark bands being blue shale, alternating with the sandstone beds.



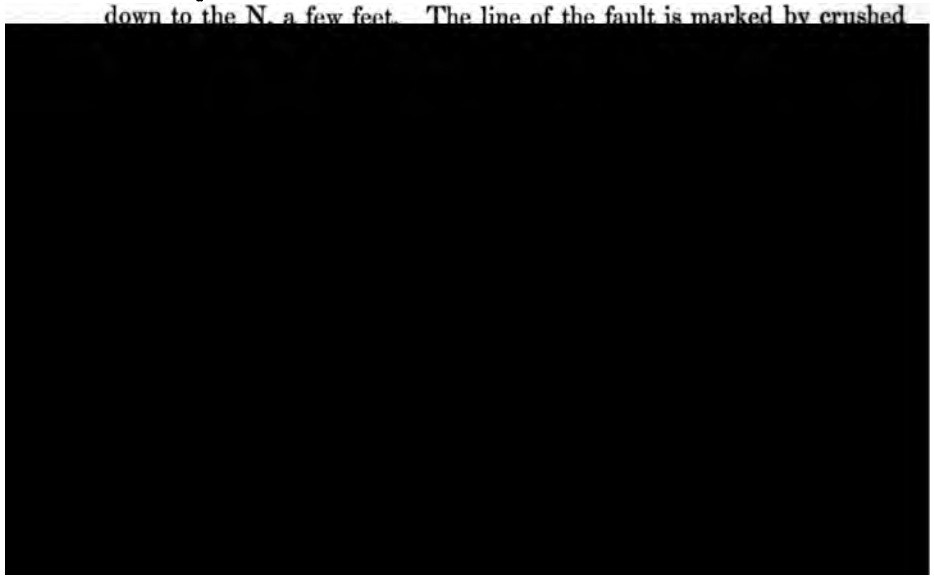
Keüper Sandstone.

About Longdon, as already observed, the Keüper stone is thicker than usual, and occupies a wider area. It is full of oblique lamination. The church is built of it.

It is very generally observable that the oblique laminations in this rock dip in one direction, though not at one constant angle.

In this neighbourhood, the variegated marls below the Keüper are well exhibited along the edges of the hills, which are crowned by the sandstone.

About a quarter of a mile to the S.E. of Welland, in the marls below the Keüper, is a line of fault directed to the N., 80° W., which throws down to the N. a few feet. The line of the fault is marked by crushed



24. NEW RED MARLS (UPPER GROUP).

(Thickness, 200 or 250 feet.)

This is the most continuous of all the members of the New Red series. The conglomerates (No. 20) cease a little south of the Malvern Hills, the red sandstones (No. 21) terminate against the south-eastern part of May Hill, and the lower marls and the fossiliferous sandstones against the Old Red border of Dean Forest, but these upper marls continue in a long and winding course, between the outcrops of the lias and Keüper, from near Longdon to Corsewood Hill, thence running up N.W. into the synclinal of Birth Hill and Berrow Hill, and again into the hollow between Bury Hill and Dobs Hill, and turning round this hill on the western side to Corse, Limburg Hill, Catsbury Hill, Rudford, Churcham, Minsterworth, Westbury-on-Severn, and Broadoak and Newnham.

From Newnham these beds are under the Severn, or under Arlingham Marsh-lands, as far as Hamstalls. Here and at Phipps's Grove they are seen in a very narrow band, and so continue to Pyrton Passage, having on the west old red sandstone, and on the east lias. At Pyrton Passage they are separated from the Old Red by the intervening ridge of Silurians which commences here. They continue in a very narrow course (about 100 yards), unconformably resting upon the Silurians, as far as Nubbes' Ash, where the railway cutting exposed their contact with lower lias. Here their area widens and is traced southward (always in contact with Silurian strata) to near Huntingford Mill, and from thence, in a winding and narrow band, sometimes touching Silurians, but generally abutting against the Old Red, mountain limestone, and coal, of Tortworth, Cromhall, and the Kingswood district. Patches of the same beds occur on the western side of these same districts, under similar relations to the same strata, and the lower part of the red marls is on both sides marked by the occurrence of thick beds of magnesian conglomerate, which rests in narrow fringes and small, insulated masses against the outcrop edges, and on the surfaces of the older strata. Thin layers of greenish marl occur in many parts of these strata, and they are often accompanied by very thin laminæ of white sandstone (*k*), never observed to be fossiliferous. Light-coloured bands of marl occur frequently in the upper part of the series, and a band of this colour, thicker than any of the others, lies on the top of the deposit and marks the boundary of the New Red system.

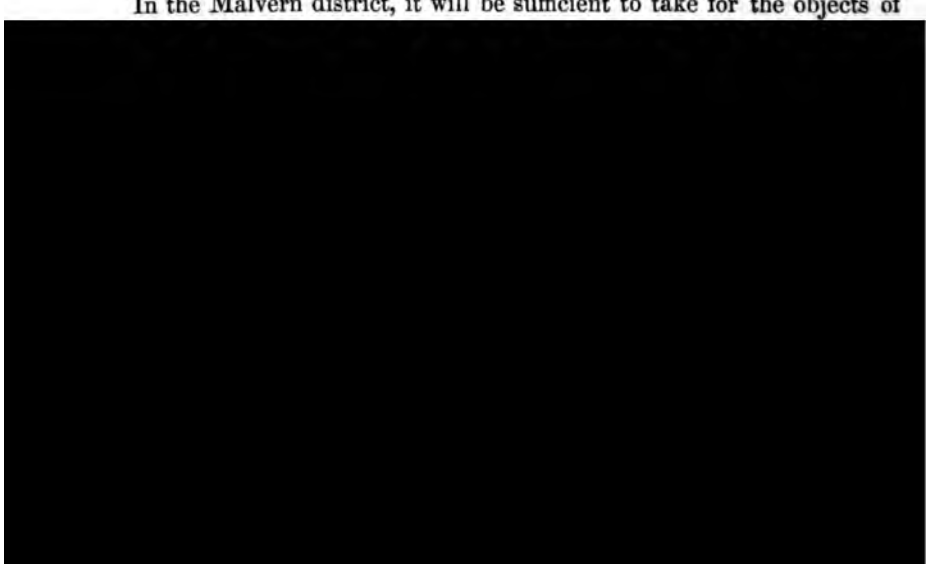
This division of the red marls forms generally low and rather plane ground, but in particular places, especially in synclinal hollows, it rises into insulated hills, such as Limburg Hill and Birth Hill, which were once, perhaps, capped by lias, and Berrow Hill, which is so at present.

ORIGIN OF THE STRATIFIED MASSES.*

To determine the true origin of the stratified masses, especially the more ancient of them, one of the most important *desiderata* in geology, can never be accomplished except by the solution of as many partial problems as there are natural districts of country, and associations of rocks. To affirm generally, that limestone is an extract from clear water by the force of invertebral organization, that sandstones and clays, and oxide of iron, are primarily due to volcanic action, may be sufficient for the cabinet microcosmist, but can never satisfy the field geologist. To him limestone appears under various aspects—here of coralline, there of testaceous, elsewhere of sedimentary origin: it is of crystalline, nodular or laminated structure, that is to say, aggregated by molecular, or accumulated by gravitating forces. Conglomerates, sandstones, and clays of various kinds declare themselves the fruit of littoral agitation, and marine and fluviatile currents, combined with the unequal falling velocities of matter, and varying depths of the sea. From what ancient lands, through what channels of the sea, were these sediments brought; at what depths, and under what conditions, did these mollusca and zoophyta live; when and how were those lands and sea channels displaced; these innumerable races of being extinguished, and succeeded by other equally active generations? These, and such as these are the problems which suggest themselves to inductive geology, as at once practicable and productive.

Abandoning then the general question of the primary condition of the matter of limestone, sandstone and clay, for the limited inquiries already indicated, let us collect what evidence can be found in the Malvern district, touching the *mode of accumulation of the strata,* and the *proximate origin of their materials.*

In the Malvern district, it will be sufficient to take for the objects of



SANDSTONES.—In which the arrangement of the parts is due to quick deposition in water considerably disturbed, or current-movement on its bed, but through which the diffusion of sand grains was limited.

CLAY . . In which the arrangement of the parts is due to slow deposition in water but little disturbed, and of which the materials have been derived from wide aqueous diffusion (clays, shales, &c.).

LIMESTONE.—In which the arrangement of the parts is principally due to molecular forces operating in tranquillity, and the materials have been gathered from very wide diffusion through water (crystalline, concretionary, and bedded limestones).

Conglomerates.—In the vertical section (page 51), the Malvern strata are represented, and on a first view of it we perceive that through the whole series (4000 feet in thickness) below the old red sandstone, the occurrence of conglomerates, marking the strong action of water, is limited to the lower but not to the lowest part; viz. to about the middle of a great group of sandstones (Nos. 1, 4, 5), the upper part of which is laminated, and the lowest part massive, but neither conglomeritic.

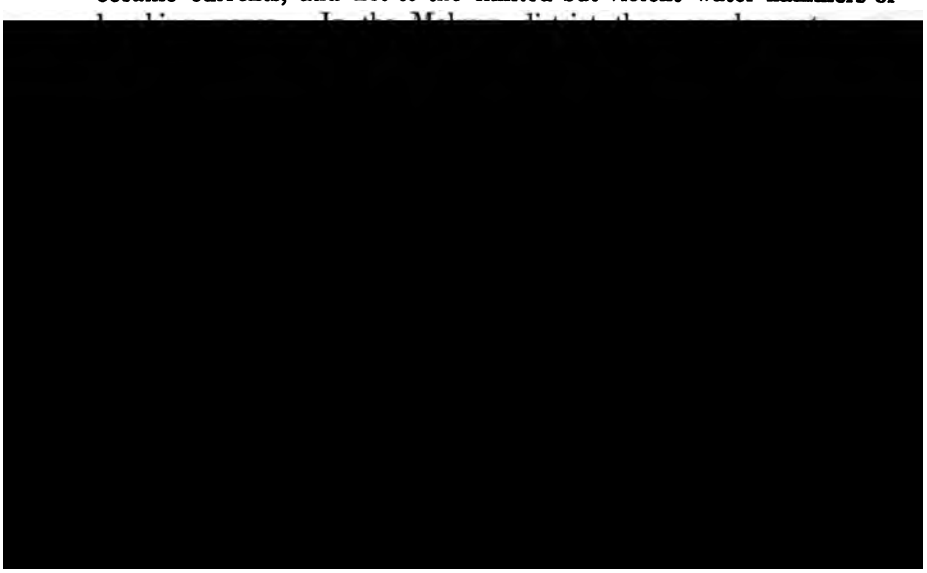
Looking carefully into the composition of this conglomerate (No. 4), we find it to contain only a few pebbles and fragments, which can be certainly referred back to a definite local origin; these are syenitic and felspathic fragments of the same nature as the rocks of the Malvern hills adjoining, to which, therefore, or to some now buried points of similar and coeval rocks, we may ascribe the original site. In a particular locality, beneath the Worcestershire Beacon, as already observed (p. 66, *et seq.*), this inference is established beyond doubt, for beds belonging to No. 5, and the Malvern syenites appear there to have been fully consolidated, and subject to disruption and waste, previous to the age of that particular shelly conglomerate into which they enter so largely. But regarded as a mass, the very small quartzose and felspathic fragments which make up the substance of these conglomerates, cannot be so surely identified as to be referred back to any particular geographical site, or any certain rocky origin.

It is however probable, that these constituent pebbles were not derived from the detritus of the syenitic range. The conglomerates extend too far beyond the Malvern district, they contain too little of hornblendic admixtures, and in other respects betray too little of local affinity to this range to allow of this being admitted. Nor are examples wanting of pebbles accumulated under cliffs which yield none such. In the plains east of Malvern, we find on the surface abundance

of gravels, which have been drifted by a modern sea current, in a line nearly north and south; and only locally mixed with the peculiar detritus sent down to the same sea from the Malvern Hills; an older case of the same kind occurs in the conglomeritic beds of the lowest new red sandstone of Knightsford Bridge, which is full of trappean and metamorphic rocks not derived from the adjoining chain, and cases of similar meaning may be seen on every modern rocky coast where the tide sets along shore.

All that can be safely concluded from the occurrence of this small-grained conglomerate along the western sides of the Malvern Hills, is, that during a certain period of the deposition of the Silurian strata, an oceanic current prevailed there. This current may be supposed to have acted on a line nearly north and south, as traces of the same conglomerates occur from the Abberley Hills to May Hill; and as similar effects have been extensively noticed elsewhere, on the west, in the course of the survey (as about Church Stretton), in coeval strata, perhaps the conclusion may be admitted, that in very early Silurian periods, the line of the Malvern Hills may have been a line of coast, confining a sea on the west, whose bed was traversed by currents capable at intervals of drifting gravel in broad sheets, as may happen now on some parts of the bed of a shallow and stormy sea like the German Ocean.

That these conglomerates are not properly *beaches*, though their accumulation may have been frequently near the shore, will be evident from the following facts:—First, they are *beds*, really stratified, and often, in a single bed, are pebble bands and fine sands, which scarcely happens in a true beach; and, secondly, they are not found wedge-shaped, or angularly-inclined, to the strata of common sandstone, as pebble beaches are found in relation to modern sandbanks, but interstratified with the same, and evidently subject to the same broad oceanic currents, and not to the limited but violent water-hammers of

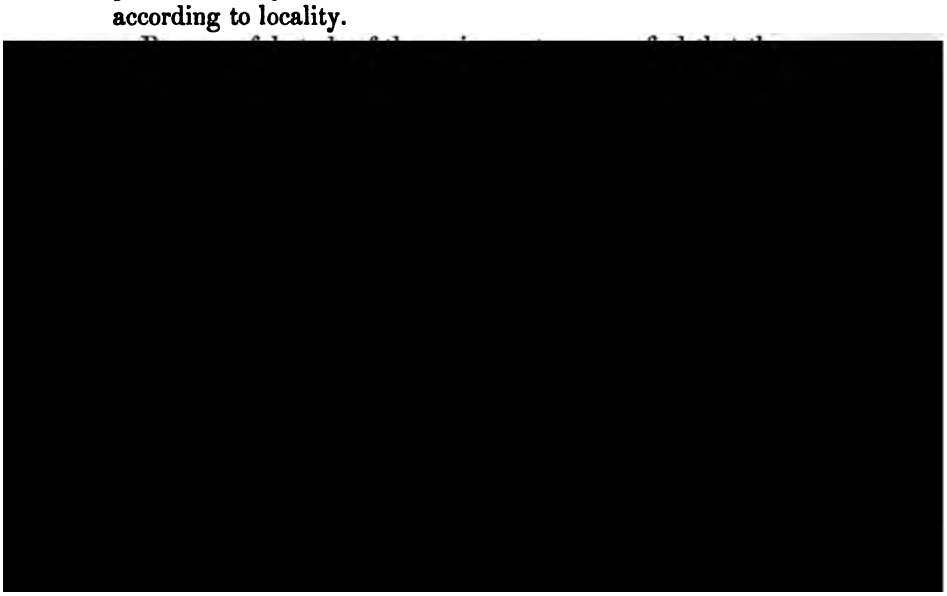


agitation, and unless the fucoids, which appear in it, be admitted in evidence, there are no facts on which to ground an opinion as to the depth of water in which it was formed. Above the conglomerates, and partly associated with them, the ordinary thin-bedded Caradoc sandstones, alternating with laminated shales, indicate deposition in water of no great depth, subject to no great disturbance, and but little traversed by oceanic currents. On the muddy bottom of this sea, various living things have left their trails; slight current or ripple marks appear; but no oblique lamination, nor other trace of rapid horizontal aqueous movements. A sea rich in small lamelliferous unattached corals; abundance of delthyroid and atrypoid brachiopoda; aviculoid, and polyodontal conchifera; a few holostomatous gasteropoda; one heteropod genus, some orthocerata, and several trilobites, but no fishes; a sea, not so shallow as to allow of laminæ extremely thin, not too deep, too far from land or the afflux of rivers to forbid separate and coextensive deposits of sands and clays, and yet quiet enough to permit these sediments to remain without subsequent horizontal displacement, or the admixture of coarser ingredients, may be safely admitted for the Upper Caradoc series of strata, as they occur in the Malvern district. Some *quiet sea* enclosed between lands which have now almost disappeared, of an extent too small for tidal tumult, receiving the spoils of a muddy river, and perhaps giving passage to a feeble ocean current, seems clearly indicated by the facts observed. Among these facts, is one of a curious nature connected with ancient organic life. The shells and corals which abound in particular parts of this series, are almost confined to its sandy beds, and almost excluded from its argillaceous beds; and what makes this distinction the more striking, is the circumstance frequently observable, that the fossils do not rest on the upper or adhere to the lower part of the thin sandstone beds, but lie concealed in a layer in or near the middle of these beds. This circumstance will again attract our attention. The direction of influx and the local origin of the sandstones may be assumed to be not different from that of the conglomerates

Shales.—Above the Caradoc sandstones, we perceive a great thickness of shales (No. 6 to 11) enclosing limestones, but no true sandstones. These shales are in some places continuous with those of the Caradoc series, and may be safely regarded as the prolonged effect of the causes which introduced the argillaceous element into the upper part of that series. The tranquillity of deposition which has been claimed for the Caradoc series, may on still stronger grounds be allowed to these finer sediments, for they are absolutely without evidence of any agitation. A wide diffusion of fine sediments in water, and the slow settlement of these on areas far removed from littoral disturbance, and

occupied by a considerable variety of organic beings, is clearly indicated. The extreme thickness and uniformity of these deposits implies a considerable depth, or perhaps, rather a *gradual deepening* of the water, for there is not the slightest evidence or reason for admitting in this district any *violent displacement* of the level of land and sea, during the whole Silurian period. Towards the very uppermost parts of these shales (No. 11) they begin to be arenaceous, to be still richer than before in marks of ancient life, to show micaceous laminations, the trails of sea animals, a few very thin bands of coarse sandstone, and other marks of shallower and more agitated water, nearer to a shore, or to the afflux of streams. This condition of a sea growing shallower, is equally without marks of violent movement, but it gradually changes to a new state of things, viz., the introduction of the old red (peroxidated) sediments, derived from some physical region, now first opened to this formerly secluded Silurian sea; and here end at once the protoxidated stratification and the Silurian life.

Limestone.—It is in the *midst* of the argillaceous series already referred to quiet waters and a subsiding sea-bed, that the limestones of the Malvern district are developed in three principal bands, separated from each other by shales from 500 to 1000 feet thick, and more or less diversified by bands of limestone balls. The three limestone rocks now to be noticed *interrupt* the otherwise uniform series of argillaceous depositions, yet not so completely but that in each mass of limestones are many interlaminations of shale. The limestones are also not so uniformly developed as to offer no remarkable differences. Each of them varies. The lower or Woolhope limestone is most distinct and most calcareous in the southern part of the district; the upper or Aymestry rock is most prominent in the northern parts, and in some parts is hardly traceable; the middle rock is in one or more bands, according to locality.



coral growth could evidently happen in *all parts* of these shales, encouraged this growth *especially* at three principal epochs of time? An examination of the history of modern coral reefs, according to the evidence of several voyagers, in particular Mr. Darwin, furnishes a ready answer. It is only within moderate depths from the surface of the sea that coral *reefs* are formed by the secretions of the Polypean races. This depth may be estimated at 100 feet, and by applying this leading consideration to the case before us, we have the following general view.

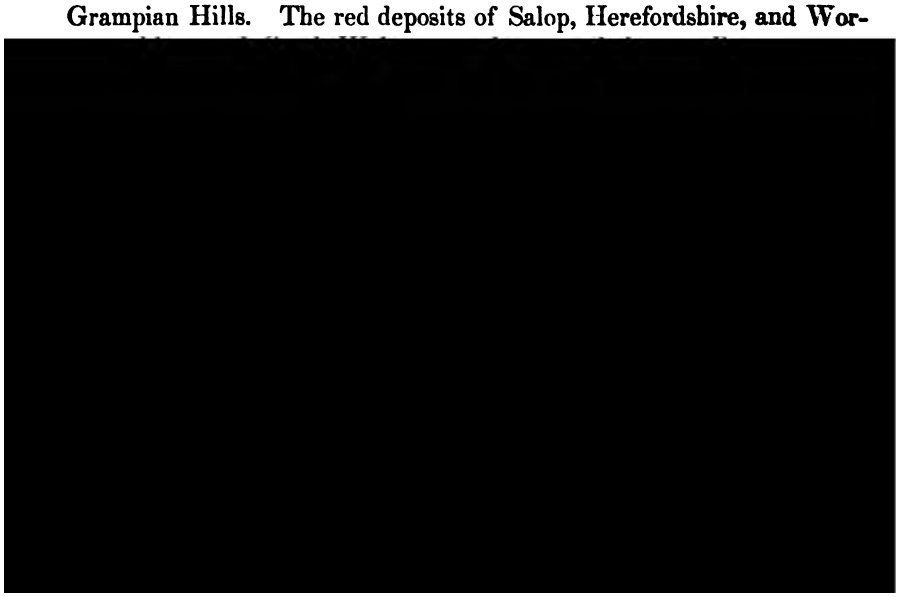
After the formation of fine conglomerates in a shallow ocean full of currents, the bed of the sea underwent slow and continued subsidence; the deposition of thin shelly sandstones in greater tranquillity followed; then, the subsidence continuing with still more quiet, the shales fill. But during three principal periods this general subsidence ceased (or became indefinitely slow), so as to allow of the shaly accumulations raising the surface of the sea-bed to the point of abundant coral growth. Then, not universally, but very extensively through the Malvern district, coral growth with the accompanying shell accumulations and crinoidal additions happened, and continued till the conditions were again changed. These subsidences and interruptions of subsidence were unaccompanied by local violence *observable here*, and were, as will be shown hereafter, contemporaneous in all the eastern regions included in this Memoir. When the coral growth was feeble, the intervals of rest in the long periods of subsidence are still clearly marked by considerable shell accumulations. Indeed whole beds of limestone are nothing but shell masses. Thus in some places *Terebratula Wilsoni*, in others *Leptæna lata* make thin entire beds, just as in the vicinity of Ludlow and at Yeo Edge *Pentamerus Knightii* constitutes by its shells a solid and valuable limestone rock. As we find the lower (Woolhope) limestone most developed in the southern part of the Malvern region, and see it a still more considerable rock on the slope of May Hill, so we may admit the interval of rest in this part of the sea to have been most decided in the early period. In like manner the enlargement of the Aymestry rock towards the north and north-west (which is confirmed by the facts observable about Ludlow) leads to suppose the interval of rest in that portion of the sea most decided in the later period. The middle limestone, the most characteristic of all, is not apparently influenced in its development by any merely geographical relations.*

Microscopic examination of these limestones detects, occasionally, minute coralline structure, but no clearly defined foraminifera. The

* The lower members of many systems of strata (as the coal formation) are more continuous than the upper. They may be regarded as expressing the full effect of new physical conditions.

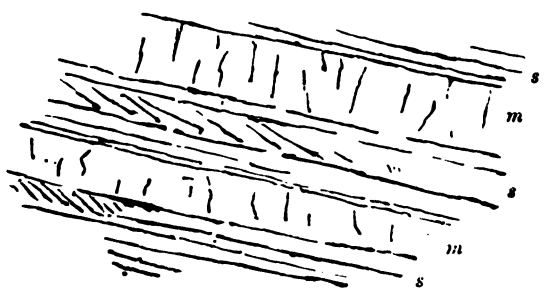
structure is often such as belongs to the dense parts of a modern coral reef, viz., a crystallized mass, in which the organization of half dissolved cells may be partially discerned. Sometimes the structure is decidedly oolitic, the grains being of various and considerable magnitude. This is most observable in the Wenlock limestone of the Malvern range.

The Old Red Sandstone, a mass of peroxidated sediments, with a few admixtures of calcareous rocks, is evidently derived from a source distinct from that which yielded the Silurian sediments. It is not merely the colour that varies; the sandstones are very laminated and very micaceous; the argillaceous beds are of a more marly texture; the limestones are concretionary, and mixed with these marls, and the conglomerates lie at or near the top of the series. This great mass of beds, 7000 feet thick in the southern part of the district, is scarcely seen farther north than Wenlock; it also grows thinner towards the west, being only 3500 feet thick in Pembrokeshire; it dwindles away to the south of the Severn, and is not known at all to the east thereof in the districts of Dudley or Charnwood Forest. It is equally unknown in the district of Craven in Yorkshire. This does not seem explicable by unconformity of stratification, but rather requires us to look westward and north-westward for the sources of the red sediments, and to a sea barrier preventing them from flowing to the eastward. In conformity with this supposition, the red deposits round the hills embraced in this Memoir, bear the character of wide diffusion in water not greatly disturbed, but yet full of local currents, a character which runs through much of South Wales, but in several parts of the south of Ireland conglomerates begin to prevail. Conglomerates, having their origin in disturbances of the neighbouring hills, also prevail around the mountains of Cumberland, the Isle of Man, the Lammermuir, and the Grampian Hills. The red deposits of Salop, Herefordshire, and Wor-



miles in particular situations, and yet during the whole operation the sea-bed, in this quarter, may have been so raised by sediments as to be at no time far below the surface of water. The sediments thus deposited have been often again disturbed by currents, so that the sands have acquired the oblique lamination, characteristic of the *pushing action* of water.

It is only the limestone (called cornstone) of this system which requires special mention. It is not in general distinctly bedded, but a mass of roughly aggregated nodules, or a number of detached lumps, imbedded in marls. The texture is crystalline, and no organization has been found in it by the microscope. The arrangement of the lumps is sometimes very singular.



In the annexed vertical section, *m* represents the marl beds, with cornstone lumps, alternating with sandstone beds (*s*), in which oblique lamination, indicating current movement, often obtains. The cornstone lumps are seen in masses variously twisted, but generally in elongated pipe-like figures, arranged at right angles to the planes of stratification, and leading in a remarkable manner to the supposition that, in the originally horizontal position of the beds, causes operated to produce the extrication of gas, which, passing upwards through the red mud, left sinuous tubular channels, afterwards, *in some instances*, filled by a calcareous infiltration (cornstone), but in other cases with whitish or greenish protoxidated clays, and small lumps of the same calcareous substance. The evolution of such gases may be ascribed to decomposing sea-weeds.

The Coal in the vicinity of the Malvern Hills (p. 104) is deposited on Old Red Sandstone. The circumstances connected with its origin are rather to be gathered by analogy from the inferences established in other districts than by direct observation in this. The absence of mountain limestone from the whole line of coal outcrops between Newent and the Clee Hills, appears to indicate that there was no considerable subsidence of the sea-bed under this area, from the termination of the Old Red deposits to the date of the coal. A little north

and a little south of this area the limestone is deposited between the coal and the Old Red, but it is thin (only a few yards in the Clee Hills). As we recede from this area, toward Somersetshire on the one hand, and Flintshire on the other, the thickness increases much, perhaps because, in these directions, the subsidences of the sea-bed were continuous, while in the Malvern district they were suspended.

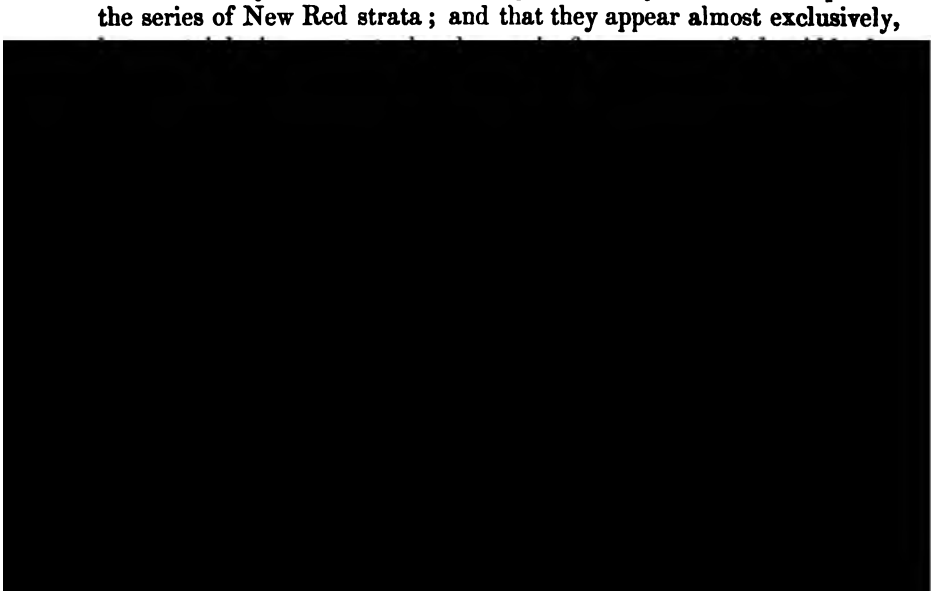
The *New Red Series* of strata offers several points of interest for the research into the origin of sedimentary deposits, but is in all the south of England and Wales almost unaccompanied by genuine limestone; the magnesian conglomerates, however, are locally plentiful, and the formation of them is worthy of careful attention. In this great series we have the—

Calcareous deposits,
Argillaceous deposits (locally gypsiferous and saliferous),
Arenaceous deposits, and
Conglomerates.

And the history of these can be, at least in general terms, confidently sketched.

Commencing with the conglomerates, we may remark, first, the peculiar circumstances of the accumulation of the lowest beds, which lie in particular recesses, and are abundantly heaped in particular areas around the Abberley Hills and the Malvern Hills, but are scarcely known about May Hill or Tortworth. The conglomerates which margin the Palæozoic rocks of Somersetshire are due to similarly local causes, and being of various ages, some of them may be comparable to the pebbly rocks of Malvern, but generally they are of later date.

The general facts concerning these conglomerates are, that they lie wholly against the eastern edge, or rest on the eastward slopes of the Silurian and syenitic rocks; that they occur only in the lowest part of the series of New Red strata; and that they appear almost exclusively,



sands and pebbles. Fourthly, a depression through which runs the Leigh Brook. From this point to the south end of the Malvern chain, about 13 miles of exposed ancient coast, we find no considerable accumulations of this nature; but the whole of the south edge of the Malvern and Ledbury Hills is margined and covered by thick though not very wide conglomerate bands, of which the pebbles seem to have been gathered from the adjacent lands and cliffs. This lowest New Red conglomerate is thus clearly shewn to be of the nature of an ancient beach, and its formation is obviously a consequence of the great and violent displacement of the rocks which followed the deposition of the coal strata, and of the new currents thereby occasioned. Previous to that epoch, the oceanic accumulations (Old Red) were abundant on the west of the Malvern and Abberley chain; after it, that western land appears to have been elevated and exposed everywhere to great surface waste, as well as on the east to the violent action of tides and storms, an action which seems to have been continued into the latest tertiary and diluvial eras.

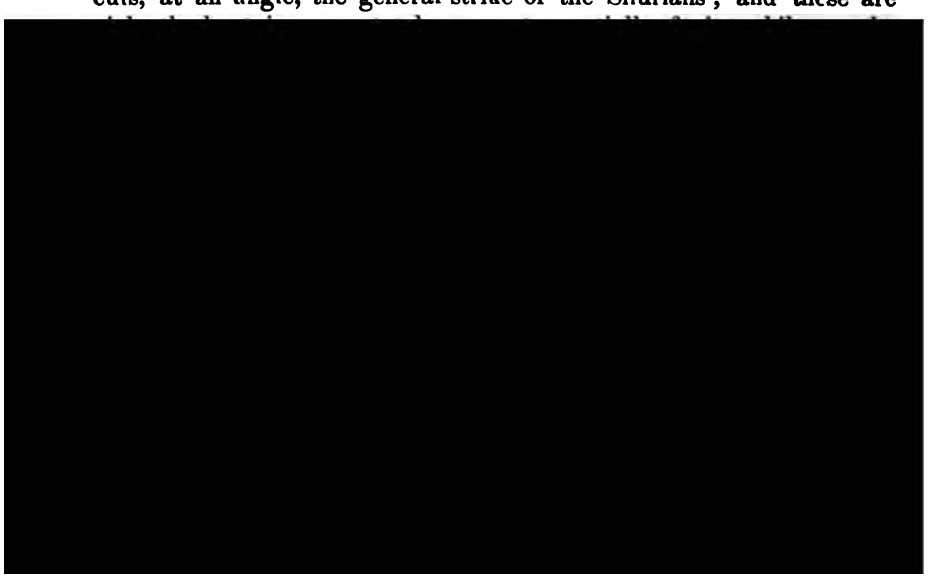
The arenaceous parts of the New Red system are so remarkably full of oblique laminations, that no doubt can exist of their having been accumulated in water of small depth, disturbed by currents which varied frequently in direction. These laminæ are inclined in various directions and at various angles, seldom, however, deviating so much as 30° from the horizon. The lower parts of this sandy series are frequently mixed with well-rounded pebbles of quartz, and various other kinds of stone, for which a local origin may perhaps be found; but it is difficult to point to the source of the far more abundant red sandstone itself. The same difficulty attends the consideration of the red marls, which generally succeed above, but which are also so frequently mixed with the sands as to require very similar suppositions for the purpose of explanation.

In the midst of these red marls lies the group of blue shales and gray sandstones, here called Keuper. These beds appear to have been accumulated under the same conditions as the red rocks above and below; whether the mineral matter came from some other quarter, or was deprived of red colour by peculiar local decompositions, might be doubtful, but for the organic remains which lie in the sandstones and shales. These offer considerable analogies to the fossils of the "bone beds" at the base of the lias, and thus, both by the mineral and organic characters, we arrive at the inference that these Keuper beds consist of materials transported from the same local centres as those which, in later times, yielded the arenaceous beds of the oolitic system. They are, in this point of view, to be regarded as the first step toward that great change, of which the bone bed is the second and most strongly marked indication.

POSITIONS OF THE STRATA.

The position of the strata in the Malvern district is principally dependent on the line of the Syenitic Hills; from which, in a general sense, the Palæozoic rocks may be said to decline westward, as far as the great synclinal beyond Ledbury, and the Mesozoic strata eastward, as far as the Severn. The westward inclination is far from uniform. It is, in fact, in all the region due west of the Syenitic Hills, except near the Wych, complicated with anticlinal and synclinal curves, which widen the exposed surfaces, and multiply the outcrops of the Silurian strata. By reference to the sections on pp. 7, 82, 92, this peculiarity may be understood. Opposite the Worcestershire Beacon is one anticlinal flexure; a little further south, the steep-bedded section from Brock Hill towards the Wych shews none. But nearer Ledbury, both north and south of that village, are several short anticlinals and synclinals, constituting a remarkable and complicated system of undulations, interlocked and connected like the interrupted folds which appear in drapery, when it is forced into accommodation with an irregular surface.

On the northern and southern sides, the anticlinals and synclinals above noticed end, by sudden flexures and depressions; the flexures being nearly at right angles to the main strike, and having, in each case, the effect of turning the strata suddenly inward towards the Syenitic chain, the dips along these curved parts being on the north side northward, and on the south side southward. On the north side, the series of strata thus contorted is not discontinuous, for the uppermost Ludlow Rocks appear under the lowest Old Red marls and sandstones, and the same is the case in all the north-western margin of the tract; but in the south-western parts (near Ledbury), the Old Red boundary cuts, at an angle, the general strike of the Silurians; and these are



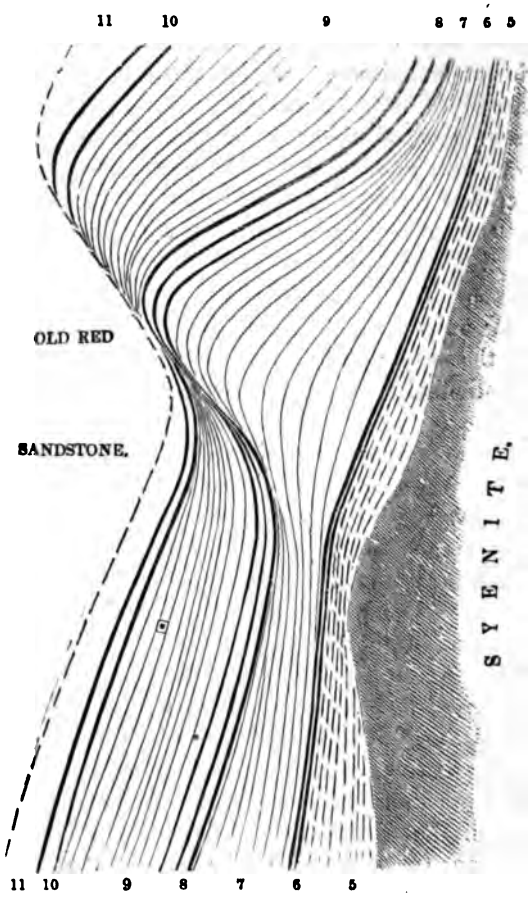
In the Malvern and Woolhope districts, three lines occur of these remarkably violent inclinations on the western side (see Diagram p. 139). *a*. Near Mordiford. *b*. Near Ledbury. *c*. Against the Malvern Hills. The steepness of the dip in these three cases augments towards the east, and against the Syenitic chain the beds often pass the condition of verticality, and overhang towards the west 100° or more.* This "reversed" condition, as it has been called, appears again and very distinctly, in the northern part of the Malvern district, towards Knightsford Bridge, and still more distinctly and frequently in Ankerdine, Woodbury, Wallsgrove, and Abberley Hills. In these latter instances, the nature of this case of "reversal" is perfectly clear. It is a case of anticlinal curvature on an axal plane which dips eastward.

From the circumstances now described, it follows that lateral pressures were exerted over the whole area, from the Abberley Hills to the southern parts of the Malvern district, and from the plain of the Severn to the valley of the Wye; it will hereafter appear that the movement extended southward to Tortworth. The newest strata subjected to these pressures are, in the Malvern district, the Old Red Sandstone beds; but in the Abberley district, west of May Hill, and at Tortworth, the Carboniferous system has been subject to the same influence. *The great flexures of strata in all these districts, therefore, were not completed till after the Carboniferous period.*

It is remarkable that, in the whole Malvern district, flexures of strata abound, but abrupt faults are scarcely to be anywhere traced in the space lying west of the Syenitic ranges, except on the east side of the Ledbury Limestones (p. 82). The following diagram represents the course of the strata as they are violently twisted, rather than really cut through, at Winning's Farm, west of the Wych. (On the coloured map, the drawing is *nearly* correct.) On a first view, this curious case seems sufficiently explained by a fault in a north-west direction, throwing down to the south-west; and though careful scrutiny demonstrates the displacements to be really by flexure, this is so violent as to be, in fact, equivalent to a fault, practically.

But it is not equivalent theoretically. For the almost universal facility of flexure among the Silurian strata of Malvern (and the adjacent districts), in a period so long posterior to their deposition, implies in them a certain want of induration which might be, or rather must have been, accompanied by much extensibility. On looking narrowly into this matter, there is reason to think that the Silurian Limestones have been often *broken*, while the laminated shales and sandstones

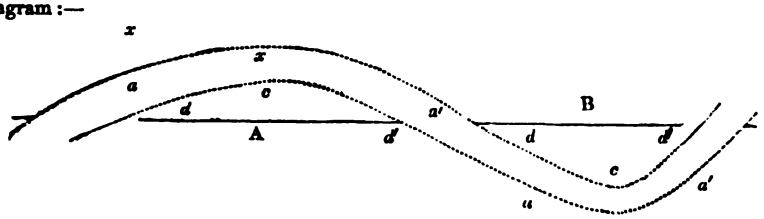
* Prof. H. Rogers has described similar phenomena on the western side of the Alleghany Chain (Brit. Assoc. Reports, 1843).



have been *bent*: the induration of the former, being dependent on different causes from that of the latter, may be thought to have been of earlier date. But there is yet another observation to be made. The

The rarity of faults, the absence of mineral veins, and the extremely slight effect of metamorphism in the Silurian strata of Malvern, are accompanied by a *total absence of real slaty cleavage from all these strata.* This immunity from slaty cleavage belongs to nearly the whole of the Silurian districts of England, specially noticed in this memoir; there being only very limited traces of this structure, parallel to a fault in

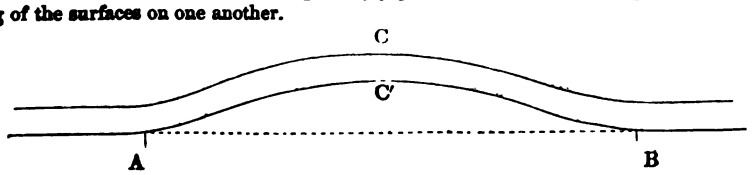
but if they appear continuous, the striæ are usually parallel over large surfaces. 3. Very extensible beds (as anthracite coal) are squeezed and altered in thickness in the flexures. Upon the whole, then, it may be safely concluded, that in violently arched strata, the beds have been somewhat displaced relatively to each other, and the parts of them have become discontinuous; so that the line of curvature of the beds must not be taken as the exact measure of the extended beds, and much less so of the beds before they were bent. Looking at the subject as a mechanical problem, we shall find it quite improbable that in a thick series of strata, of limited extensibility, and subjected to violent flexures, any one bed should remain continuous over the arches, without movement on the adjoining beds. The probable condition of such a series so bent, may be illustrated by the following diagram:—



1. If a tabular, or stratiform mass, *free at the ends*, be bent upward (as from A), or downward (as from B), or in opposite directions at two, or any greater number of points, it will be *extended* on the convex, and *compressed* on the concave side. The extensibility and compressibility being limited, there is a line as *a x a'*, on the outside of which, the parts will be over-extended, and will be *broken* asunder; and another line as *d c d'*, within which the parts will be over-compressed, and will be *crushed* together. Between these lines, the mass will remain continuous; the interval between the lines which measures the thickness of this mass, diminishing with the radius of curvature.

If instead of one continuous stratum, we take a number of non-adherent superposed strata, they will slide endways on each other, so that all may sustain equal tensions, and all be equally subject to fracture and crushing.

Between these two suppositions the stratified rocks are really conditioned. The strata are for the most part slightly adherent; and thus we find in one system of arched displacement of rocks, fracture from over-extension, crushing from over-compression, and end-movements of bed on bed, indicating the tendency to equalize the pressures. If the beds were also subject to strong lateral, or end pressure, and were very extensible, the curvatures might become extreme, with elliptical vertices and sub-parallel sides, and the inner and exterior strata adjusted together by great end-movement, owing to the free sliding of the surfaces on one another.

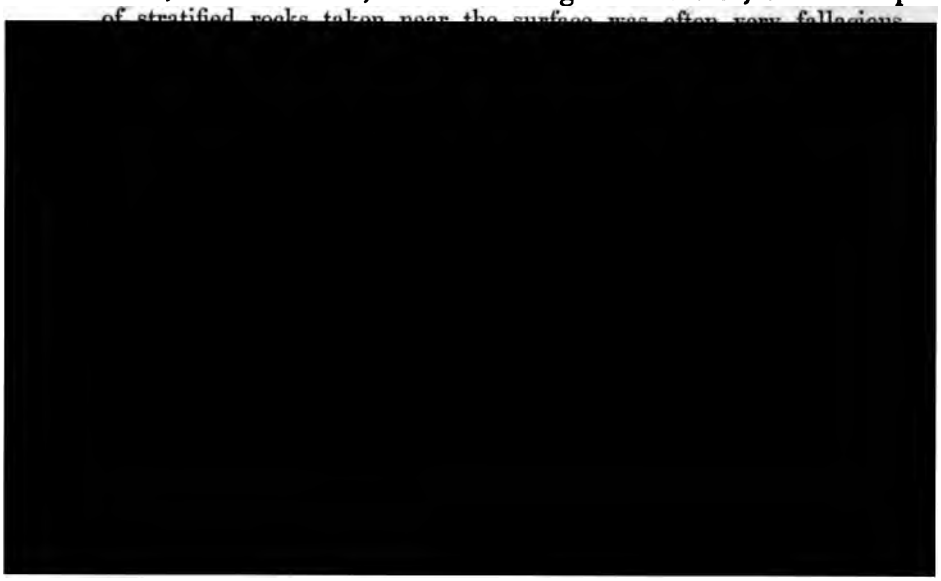


2. If the stratified mass, instead of being free at the ends, were *fixed* there, so that the part below the line A B should remain perfectly undisturbed, the results of vertical pressure would be different. The mass if raised between the points A B, by a general pressure, will

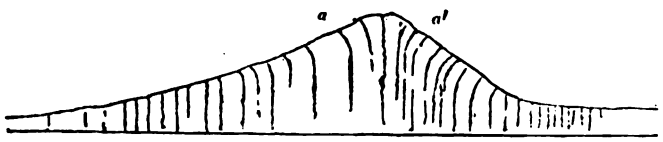
the Ludlow Rocks of the Abberley Hills at Ankerdine; parallel to a fault in the limestone at Woolhope; in the broken ridge of Shucknall; and parallel to a fault in shales of the Old Red series at Flaxley, the terminal point of the May Hill district. It does not appear at Dudley; on the other hand, through all the western parts of Wales, cleavage is of almost general occurrence in strata older, of the same age, and much younger than these of Malvern. It there extends upward to the shales of the Mountain Limestone series, (West Angle Bay, in Pembrokeshire). The same thing occurs in Ireland (south of Cork), and in North Devonshire. From a consideration of these instances, it appears that cleavage is a structure not necessarily induced in Palæozoic Rocks (to which in Britain it is confined), coincidently with anticlinal, or fault movements; nor in simple dependence on their antiquity, or contiguity to pyrogenous masses. Its dependence appears to be as distinct on the geographical area, as on the geological peculiarity of the rocks; each of these offers *favourable conditions* for the development of this structure, but the *general agency* to which it is actually due, is an unresolved problem, most probably to be referred to electro-dynamics.

The phenomenon of *reversed strata*, to which attention has already been called (p. 71, &c.), as occurring in the Malvern Hills, from Walm's Well northwards, and increasing, though unequally, in distinctness through the Abberley Hills, is deserving of special consideration in geological dynamics. Cases of this kind can hardly be said to be rare; but for one example of *real reversal* of *beds*, many can be counted which are only *apparent*. There are causes in daily action, which, when their effects are accumulated by years and centuries, produce apparent reversals, and the circumstances which accompany them are easily traced, and are very instructive.

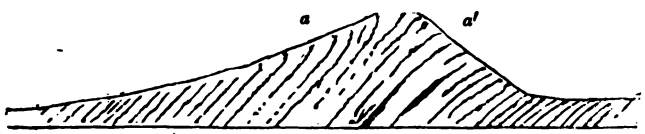
From long habits of sketching the appearances at the outcrops of strata, we were aware, when examining North Devon, that the dip of stratified rocks taken near the surface was often very fallacious



beds are really vertical, as in the annexed diagram, their terminal



portions appear on each side dipping into the hill; and with the same general form of the surface, beds which dip, as shown in the next



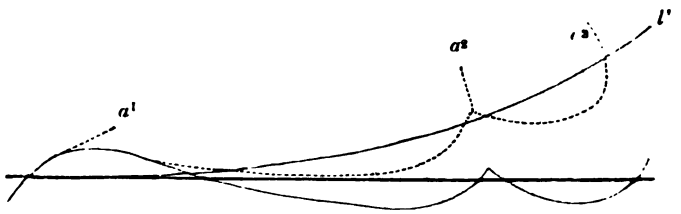
figure, may have their dip reversed on one face (*a*), and reduced to horizontality on the other (*a'*). This arises from the surface actions, which continually tend to *loosen* the rocks in the first instance, as far as frost, vegetation, moisture and other agencies extend, and finally as far as the vertical and lateral pressures of the loosened masses can operate. In steep hill sides and laminated beds, this is to the depth of several feet, or even yards, and thus it happens that through a great part of North Devon, in many parts of South Wales, and in the Malvern and Abberley Hills, the merely surface dips are sometimes *wrong in direction*, and the measure of dip almost *never right in amount*. (See the diagram of the Cutting in the Wych, p. 64, for an illustration.)

But notwithstanding the *correction* which thus becomes necessary, and which reduces the *anomaly* of the seemingly-violent reversed dips of Walm's Well and a few other localities, to a slight *overthrow* beyond the vertical, the fact of this overthrow is established at some places in the northern part of the Malvern Chain, may be readily admitted, after an examination of the syenite and purple conglomerates, near Cowley Park (p. 37), and allows of no doubt in the Abberley Hills. How is it to be explained? Not by the liquid pressure, or by any other peculiar action of the syenite; for, in the first place, this rock was not liquid when the flexures were produced; and secondly, the reversals are by far most remarkable where no syenite rises to or nearly to the surface.

Two modes of explanation may be considered.

According to the first, a series of flexures was produced in the Palæozoic strata, on axes nearly north and south. Afterwards, an upward general movement of the whole previously-bent region took place, this movement increasing in amount toward the east, beyond

the last of the flexures now under consideration, so as to raise the line $h\ l_2$ to $h\ l'$, and thus give to the slopes depending on $a^1\ a^2$ the character of greater dip to the west than to the east, and reversed dip at a^3, which are the phenomena observed.



Such an upward movement as this increasing toward the point A, may very probably have happened in connexion with the great fault in the eastern side of the district.

The eastern face of the Malvern chain is on a fault line sloping about 60°; and in hollows of its eastward slope still lie portions of Lower Silurian strata, to mark their original greater extent to the east. According to the view here taken, the fault-line so often alluded to, which terminates on the east the visible area of the Palæozoic strata, is of later date than the flexures, a conclusion in harmony with the inference of Sir H. De la Beche, drawn from a comparison of the faults and flexures of the great coal field of South Wales, with which, in a general point of view, the Malvern movements may be combined.

But this hypothesis leaves unexplained the greater breadth and more moderate slopes of the undulations on the west; and as, from Professor Rogers's investigations in the Alleghanies, this appears to be a circumstance frequently, if not generally, accompanying ranges of reversed strata, it seems necessary to propose a more general speculation. The sinking of the Palæozoic strata during the accumulation of their upper members, is an inference established in the last

will be a tendency to crushing in lines parallel to the axis of the basin, so as to admit of the upward passage of liquid or gaseous pressure at one or more points. If the laminated upper beds of the series were unconsolidated, and more flexible than those below, they need not be supposed to undergo crushing but bending, and elevation in lines parallel to the axis of the basin, so that the liquid or gaseous pressure might pass under them, and thus elevate them still more. Thus may superior strata for limited spaces be bent or broken independently of the lower beds, and these may be broken independently of those. If the cross section of the basin were elliptical (its radius of curvature being longer in the middle, as is probable), the undulations might be nearer together towards the sides of the basin. and their slopes might be steeper. Also, the axal planes of those elevations might be approximately perpendicular to the general curvature of the bed; and thus by combining known phenomena into one system of general re-elevation of a much subsided region of laminated strata, and coincident partial pressures, it seems possible to account for the unequal breadths and slopes of the several anticlinal and synclinal folds, even to the extreme case of the limited reversal of beds.

Attention has already been called to the few great fractures of strata which have been traced in the country between the North Malvern Hill and the river Teme; and it remains only to add, that a few slight movements of this character have been traced in the New Red Sandstones of the Severn plain, especially at Welland. They are, however, so unimportant, that we may regard the main physical features of the district to have been unaffected since the deposit of the carboniferous strata, except by the general change of relative level of land and sea, and the concomitant and subsequent waste of the surface. This waste is enormous, and the modification produced by watery action, especially in the eastern side of the district, from the period of the New Red Sandstone conglomerates to that of the Severn drift, will require further notice.

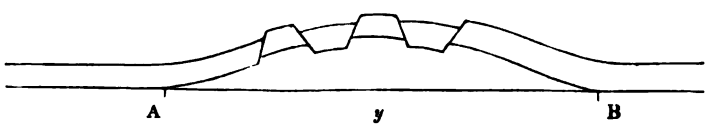
Flexures and fractures of the strata may be equally regarded as effects of pressure on large areas, and the displacements which they indicate as relieving this pressure.*

* There is, however, one important distinction between displacement by a fault and displacement by a flexure: faults, on the whole, leave the displaced beds, in a space horizontally *wider* than the measure of the beds; but flexures have often the effect of *packing*, so to speak, a certain breadth of beds, in a less width than they occupied before the movement.

The vertical pressures which occasion faults are in the end mainly relieved by horizontal extension, followed by lateral pressure; and flexures, when, as in many instances, they are the effect of lateral pressure, satisfy this purpose by horizontal contraction and vertical extensions. Certain great arched elevations and depressions may, however, be ascribed to vertical pressures operating on extensible strata.

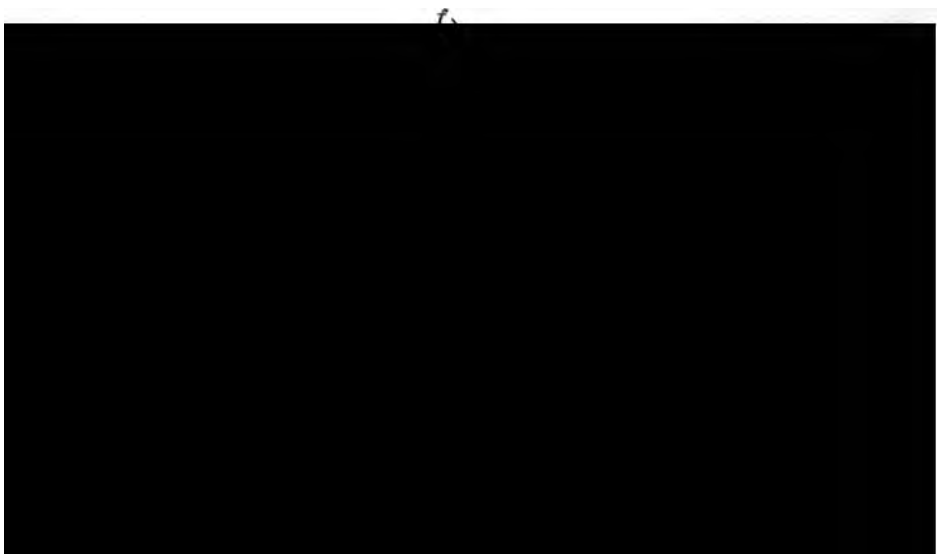
Faults and flexures considered on a large scale appear in one sense complementary phenomena. There appears to be a certain geographical reciprocity in their occurrence, so that of two contiguous districts, one will be full of faults, and the other of flexures. Thus the limestone districts of Aldstone Moor and the north-eastern parts of Yorkshire, are much faulted, while the slaty districts to the west are bent in great flexures. The coal fields of Yorkshire and Lancashire are faulted, but the strata of the Low Craven country are much bent. The Palæozoic strata of Cornwall are full of fractures, those of Devonshire remarkably arched. Speaking generally, the southern parts of England, Wales, and Ireland, are countries full of bent stratifications.

Faults, probably effects of vertical movement, may be conceived to occasion flexures by lateral pressure in the following manner:—



In the above figure, let A B represent a portion, of the thickness of the solidified crust of the earth, *y* a supporting liquid, or gas. Let A B be supposed points on two parallel lines, between which lines only the crust of the earth for a breadth A B is supposed to be displaceable by a force operating in a vertical direction. Let such force be upward, and the whole area yield to it, and be elevated with numerous fissures, more or less deviating from perpendicularity to the strata. The consequence will be, a general arch-like elevation of the whole area, accompanied by many

That faults, taken on the average, have the effect here ascribed to them, depends on a general relation between the direction of the inclination of the fault and the direction of the depression which it occasions. In the same direction that the fault *dips*, the strata are depressed.



small vertical or oblique displacements along the planes of fracture. The effect of these displacements (according to the general law explained in p. 141) will be on the whole a mutual adjustment of the wedge-like pieces as shewn in the figure, so that the whole length of the now discontinuous bed will be augmented and accommodated to the general arch; the constituent parts of which may also have been somewhat *extended* by the process of uplifting previous to fracture. The increase of length in the bed will be a quantity depending on the *number* of small displacements, their *vertical* extent, and the *deviation* of each plane of displacement from *perpendicularity* to the strata.* Now let the crust be supposed to be consolidated, or confirmed in this new form; the force to which the upward movement was due be supposed to cease; the pressure on *y*, which supported the arch, to be slowly withdrawn; the arch consequently to begin to sink again. One of the consequences will be lateral pressure toward the abutments of the arch, a yielding of the crust towards these points, and the production of curvatures, and angular displacements, so that finally, the equilibrium of pressure on *y* being restored, the extended crust will be adjusted to its new position by one or more hollows and ridges, between the points A B, more or less parallel to the axis of the original upheaval of the crust.

The lateral pressure may be unequal on the two sides of the anticlinal, so as to cause the principal secondary flexures to fall altogether on one side, and there to produce even reversed curvatures.

According to this view, then, one or more curvatures parallel to a great anticlinal elevation, are a probable consequence of such elevation. It is conceivable, that after the formation of one such curvature, it may become confirmed in position, and another may be produced by further depression of the arch, and thus several secondary ridges and hollows, may appear parallel to a very broad anticlinal.

When in any particular region, the whole of the flexures can be measured, so as to determine the amount of lateral thrust which they compensate; the least breadth of a given vertical elevation, or the least anticlinal elevation on a given breadth, is calculable. In the case of the section which extends from the Malvern Hills, across Woolhope Forest, the flexures have been measured, and if the beds of any of them could be supposed continuous throughout, the extension and lateral thrust

* See on questions of this kind, and generally on the subjects treated in the previous pages, Mr. Hopkins's Memoirs on Physical Geology, in Cambridge Phil. Trans., 1835; Phil. Magaz., 1836; Phil. Trans., 1839, 1840, 1843; Geol. Trans., 1845.

taken together which they indicate, would be one mile. But for the reasons already given, this is inadmissible. Half a mile of lateral thrust may be possible through the subsidence of an anticlinal of 10 miles breadth, and about 3 miles elevation.

On this point it seems right to remark, that besides the great faults, many minor displacements among the blocks of rock can be traced in disturbed districts, and many cracks in these blocks, now filled by calcareous spar—circumstances which tend to increase the possible amount of horizontal thrust, which may be justly attributed to the sinking of an anticlinal fractured arch.

In cases where end pressure has been effective, the beds of unequal extensibility will be unequally affected, one set broken, another set bent, so as to be forced into adjustment with the fractures of the other.

We may, perhaps, correctly regard the movements which have been traced in the Malvern district, from the earliest Silurian to the latest carboniferous beds, as one long series of effects depending on one continuously influential condition, and mark three phases of action. First, extensive and long-continued *depressions* of the ancient sea bed, through the Silurian era; secondly, a great local *elevatory* movement, affecting the same, or portions of the same sea bed, with a series of anticlinal and synclinal axes of curvature in the strata; thirdly, fractures through these undulations. In searching for the *general physical cause* of these local phenomena, it is indispensable that we first determine the true relation, in space and time, of the Malvern movements to those which have affected the coeval strata in the adjoining districts of England and Wales. The Abberley Hills first attract our attention.

THE ABBERLEY DISTRICT.

Under this title it is convenient to rank all the picturesque chain of hills, which commences at Knightsford Bridge, eight miles from Worcester, on the north bank of the River Teme, and terminates near the village of Abberley, within about three miles of Stourport. Across this chain of hills, which ranges generally north and south, are several depressions, the most considerable of which, near the village of Martley, effectually interrupts the ridge, and separates the high and wavy outline of Ankerdine* Hill, on the south, from the still higher but more continuous grounds of Ridge, Wallsgrove, and Abberley on the north.

The hills which have been named are composed of Silurian strata; but in the gap between the Ankerdine and Ridge Hills rises a huge mound of trappoid conglomerate, called Berrow Hill, crowned with ancient earthworks, and near it is a small swell of syenite. At the northern end of the eastern branch of the Ridge Hills, is a still higher and more important mound of similar conglomerate, called Woodbury, encircled by an extensive camp; and the highest ridge of the Abberley Hills is formed of the same rock, margined by the Silurian strata. The relative situation of these various points will appear in the general coloured map, and in the map of the Abberley district; and their relative altitudes are given in the following table:—

Table of approximate Elevations in the Abberley District, determined trigonometrically by comparison with the Malvern Hills in 1844 *and* 1845.

	Feet.	On what Authority.
Worcester Beacon (Malvern) .	1444	Trig. Survey of Great Britain.
Highest Point of the Abberley Range near the Hundred House (conglomerate) . . .	985	Geological Survey.
Wallsgrove Hill (Silurian) . .	880	Ditto.
Woodbury Hill (conglomerate) .	975	Ditto.
Ridge Hill (Silurian) . .	709	Ditto.
Hill End (Silurian) . . .	656	Ditto.
The Point of Syenite . .	410	Ditto.
Berrow Hill (conglomerate) .	680	Ditto.
Ankerdine Hill . . .	570	Ditto.
(Rosemary Rock, south of the Teme (conglomerate) . .	378	Ditto.
Valley of the Teme, above Knightsford Bridge	180	Ditto.

The most elevated points in the district are the hills of conglomerate; next to these the Silurian ridge of Wallsgrove.

* This name appears to have Celtic elements, but it is difficult to say what roots are combined with the word signifying hill.

The Abberley Hills are thus found to be about 500 feet lower than the Malverns. Their highest points are towards the north; the steepest slopes on the western side. From the comparatively great depression of the country around, these hills have a very striking appearance from the vales of the Severn and the Teme, claiming, indeed, to be regarded as a continuation of the Malvern chain, but with altered outlines and in more detached masses, and adorned with trees, alone or in groups. The views from the hills are very extensive and pleasing.

The rocks of the Abberley Hills form part of the same group as those of Malvern; and, on comparison with them, offer but few points of local difference. The lowest of the Malvern strata are not exposed at the surface in the Abberley district. Syenite is, perhaps, the general basis of these strata; but it is seen at the surface only at one spot, examined by Sir R. I. Murchison, between Berrow Hill and King's Common, near Martley. The circumstances of its appearance here have been already illustrated by the section and description, p. 38. We proceed then to the Palæozoic strata, the three lowest members of the Malvern series being here absent or invisible.

4. CARADOC CONGLOMERATE.

This rock agrees very well with the gray beds full of small quartz pebbles, which abound in the Storridge Hills, Rough Woods, and Cowley Park, and lie upon the purple conglomerates. It contains small masses of Malvern syenite, and rolled chips and fragments of clear quartz, arranged in irregular beds, with very few fossils. Only a small thickness of it is exposed in the Abberley district, and that only in Ankerdine Hill. Many beds have a trappoid aspect.

6. WOOLHOPE LIMESTONE.

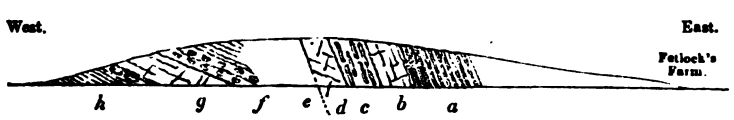
This rock, owing to the dislocated condition of the country, is nowhere seen in the Abberley Hills; the Caradoc district being bordered by the Wenlock and superior strata, thrown against it by faults.

7. WENLOCK SHALE.

This stratum is but slightly exposed in the Abberley district, occupying only part of the valley between Fetlock's Farm and the Ridge Hill, (and a narrow space under Rosemary Rock?) It offers no peculiarities for remark.

8. WENLOCK LIMESTONE.

This rock, which appears in a small area about Collins Green in the northern part of Ankerdine Hill, and in a long range from Hillside to Wall-house under Woodbury Hill, offers a complete similarity to that of the country farther south, being, like it, composed of one or more bands of solid limestone fit for the kiln, alternating with beds of shale enclosing layers of balls. The best opportunities for inspecting the succession of these strata are in the partly double line of quarries on the ridge from Hillside to Woodbury Hill. The road cutting from Fetlock's Farm across this ridge, presented the following section in 1845 :—



New Red Sandstone on the east.

a. Shales and limestone balls, the lowest very broad and lenticular.
b. Limestone, lumpy or irregular in the bedding.
c. Broad masses of limestone and shale.

The above Silurian beds dip eastward 75° W.

d. Limestone, lumpy, and much veined with calcareous spar, the bedding uncertain.
e. Pale coloured shales. (A line of twisted strata passes here N. and S.)

The beds below dip eastward 18° here, but in a neighbouring quarry 80°.

f. Series of small calcareous balls in shale.
g. Solid limestone, used for the kiln.
h. Shale, with thin balls.

The whole series, if continuous, as it probably is, may be about 200 feet thick.

A part of the Wenlock limestone, near Collins Green, and again near Woodbury Hill, is magnesiferous and reddened.

9.—LOWER LUDLOW SHALE.

This deposit is seen in the anticlinal line, between the two hills of Aymestry rock, which extend from Ridge Hill Farm toward Walls-

grove Hill, but nowhere so well as at Hole Farm, half a mile S.W. of Woodbury Hill. Here it appears nearly vertical for 100 yards, and yields many fossils, especially Trilobites.

10.—THE AYMESTRY ROCK.

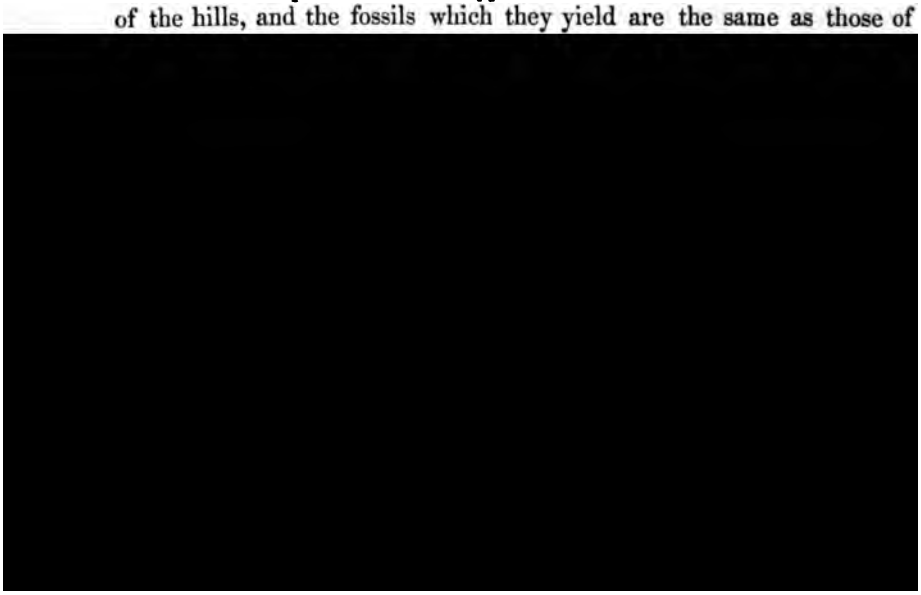
This, which is one of the most marking features of the Abberley district, appears in narrow ridges, like those of Ledbury, and presents in section similar characters to the beds at Halesend. It appears somewhat thicker (50 feet at Hole Farm), and offers one analogy to the deposits of Aymestry itself, which has not yet been found about Ledbury, viz., the presence of *Pentamerus Knightii*.

11, 12.—UPPER LUDLOW SHALE AND DOWNTON SANDSTONE.

These beds can scarcely be separated in the Abberley district, the sandy character of the upper part of the Silurians growing gradually more pronounced, till the Old Red closes the series. About Hole Farm the beds appear thus (reversed or dipping eastward 57°, 67', and 80°).

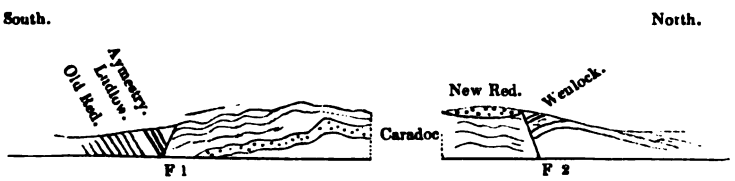
Old Red Sandstone.
Sandstones laminated and gray.
Gray sandy shales, of considerable firmness.
Sandy shales, with *Atrypa prisca*, *A. didyma*, &c.
Aymestry Rock in the state of calcareous balls, and beds with *Terebratula Wilsoni*, *Cyathophylla*, &c.

The whole thickness of these beds exceeds 250 feet. The strata are arched over towards the west at the surface of the ground. A similar succession is found at Knightsford Bridge, also reversed; and part of the series is seen in a quarry at the end of Wallsgrove Hill. There are several other exposures of the upper Ludlow beds on the western sides of the hills, and the fossils which they yield are the same as those of



The relative positions of these rocks are in some points most unexpected and remarkable, and exhibit in a striking manner the effect of enormous wrinkles and cracks in the crust of the earth. Ankerdine Hill, the most southern part of these ridges, is an anticlinal mass of Caradoc sandstone, the axis running nearly north and south. It is bounded by four faults, each throwing down (as the miners express it) the strata around the hill. The Old Red sandstone is thus brought into contact with Caradoc sandstone on the west, and the New Red touches it on the east; the Wenlock rocks are thrown into similar contact on the north, and the Ludlow rocks on the south; and it is remarkable that in each of the two cases last mentioned, the more recent strata dip towards, as if to pass under, the older.

These appearances are represented in the section below.



The Caradoc sandstone strata thus embedded between four faults are much undulated, and even suddenly and violently bent, and the crest of the hill has a corresponding irregularity of outline. The lowest of the Caradoc strata are conglomerates; and among the fragments which they include are small masses of Malvern syenites and felsparites, a circumstance confirmatory of the inference already gathered from the phenomena on the sides of the Malvern chain—that the syenitic rocks were consolidated previous to the era of these Caradoc beds.

The successive beds of the Upper Silurians, which abut against the Caradoc of Ankerdine Hill, may be seen in the quarries at the south-east end of the hill, near Knightsford Bridge.

The following diagram represents the section; the beds striking to the north 50° W., and dipping to the N.E. (62° to 66°):—

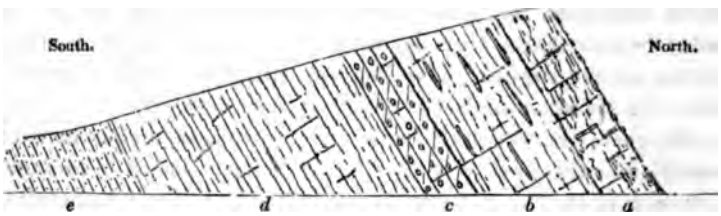
e Old Red Sandstone, very micaceous, with partings of shale; colour, partly gray.

d 60 feet thick.—Upper Ludlow. Beds of flaggy "mudstone," with a few calcareous bands; colour gray, laminations frequent, micaceous. In the upper part occur *Leptæna lata* (large), *Terebratula nucula*, *Orbicula rugata*. In the middle part a crinoid, *Leptæna lata*, *Terebratula nucula*, *Orthis orbicularis*, *Orbicula rugata*, *Cypricardia amygdalina*, *C. cymbæformis*, *Nucula* (two species), *Murchisonia corallii*, *Serpulites longissimus*. In the lower part *Leptæna lata*, *Terebratula nucula*, *Orbicula rugata*, *Nucula*, *Orthoceras virgatum*.

c 10½ feet thick.—Three beds of balls compacted together, with slight appearance of cleavage structure parallel to the fault. In the lowest of these beds *Leptæna depressa* is found. (Carbonate of copper occurs with calcareous spar in the joints of these beds).

b 28 feet thick.—Laminated shaly beds, with thin broad lenticular limestone masses. In these beds occur specimens of *Turbo corallii*. At the bottom, in the joints, are small crystals of red oxyde of copper.

a 12 feet thick.—Lumpy, irregularly-bedded limestone, compacted of irregular nodules. Large specimens of *Atrypa prisca* occur in these beds.

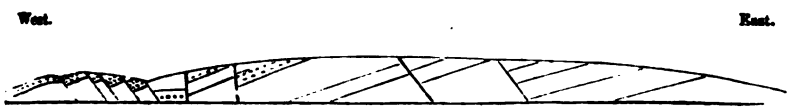


The beds *a*, *b*, *c* may be regarded as composing the Aymestry limestone series (50 feet), the Upper Ludlow beds (*d*) being here only 60 feet thick.

The Wenlock beds on the north side of the Caradoc sandstone of Ankerdine Hill dip to the S.E. about 27°.

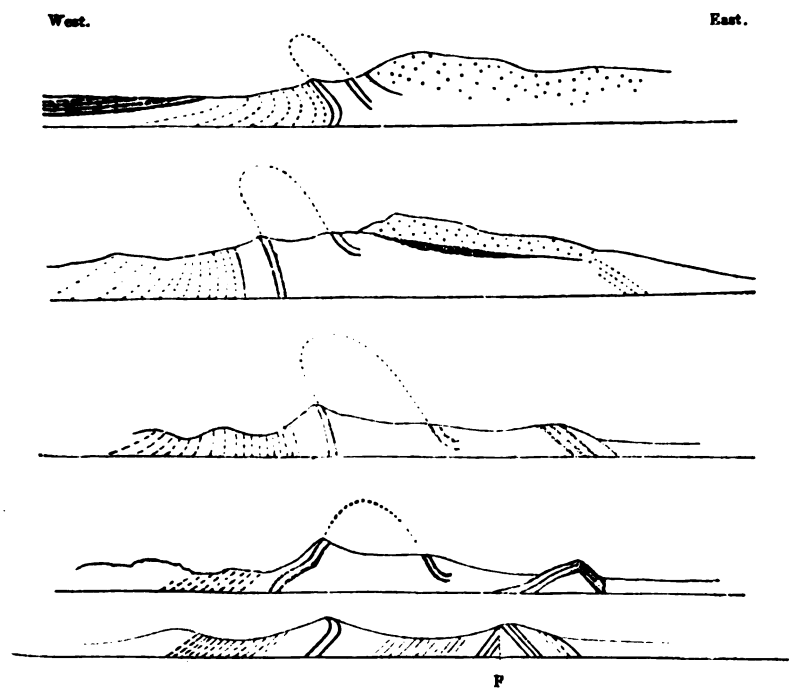
The most remarkable fact in the depression which crosses between Ankerdine and the Ridge Hills, is the occurrence of an almost continuous coal outcrop between the New and the Old Red sandstone: and where the syenite appears between these two sets of strata the coal also is present, and its shales are recognised between the syenite and the New Red. The section given in page 38 will explain this.

These outcrops of coal are traceable through a great part of the space between Ankerdine Hill and the Silurians of the Ridge Hill; and many old trials and partial workings of the coal are observable, especially under the great conglomerate mass of Berrow Hill, both on its western and northern slopes. These trials were prosecuted



Beyond this point the country rises towards the north, and the Silurian strata exhibit themselves in one, two, three, or even four bands of limestone, with separating shales between Old Red strata in the west, and New Red on the east.

The single or double western ridge of hill contains the Aymestry rock and Ludlow shales; that on the east yields Wenlock limestone in frequent quarries; but these rocks, instead of dipping in conformity to one another, exhibit the following complicated appearances at five points of the chain, taken successively from north to south.



F

In the southern part only two ridges appear; that on the west (Aymestry rock) is nearly vertical, or dips W.; that on the east (Wenlock rock) dips E., and is broken through by a fault, on the west of which in one place is the same Wenlock limestone, depressed, and dipping north-westward, as if nearly in its proper place with relation to the Aymestry rock.

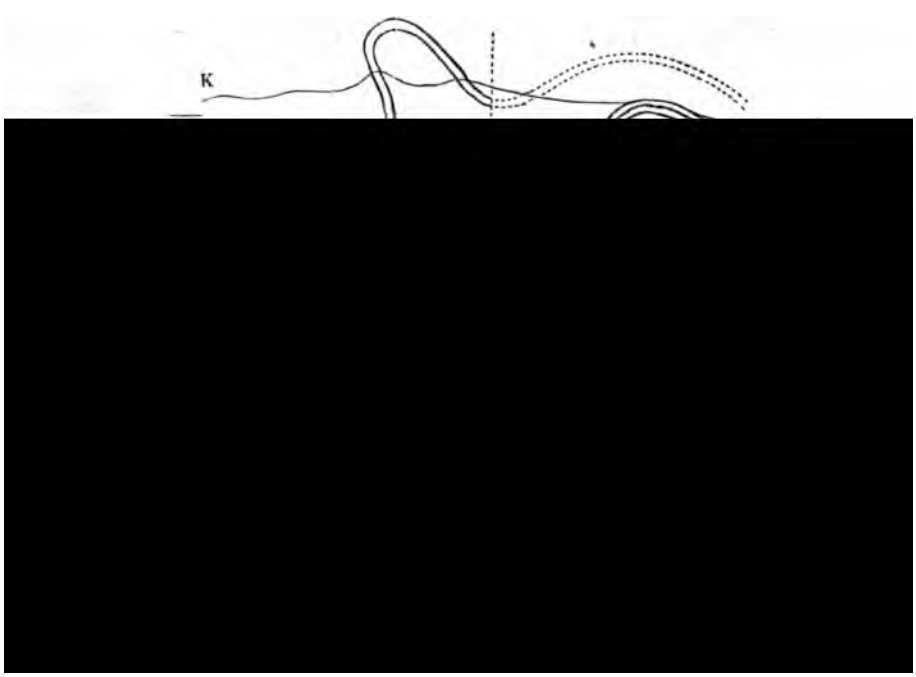
In the middle a broken anticlinal of Aymestry rock on the west is

opposed by a complete anticlinal of Wenlock limestone on the east, without any conformity between the two.

In the north the anticlinal of Aymestry rock on the west has the singular character of being folded or bent on an axal plane dipping to the east, so that the Ludlow rocks overlie the Old Red beds, while on the east the ridge of Wenlock limestone is seen dipping eastward, as if it were a superior stratum. To make this case the more extraordinary, a cap of peculiar conglomerate, forming Woodbury Hill, rests on the whole unconformably; but discloses between it and the Silurian strata, a narrow very distinct outcrop of coal and coal shales. These facts appear due to flexures and fractures of a complicated character, which may be thus in part illustrated.

The stratified crust of the earth is folded in this part of the Abberley region into two anticlinal elevations, separated by one synclinal depression.

Superadded to these folds, and probably of somewhat later date, are faults, of which one marked F, in the sections now referred to, is sufficient to account for much of the seeming complexity of the dips and out-crops. This fault, which crosses the Wenlock limestone quarry near Hillside, has the effect of elevating the eastern side. It then ranges to the N.N.W., so as to pass between the ridges of Aymestry and Wenlock limestone, as far as Woodbury Hill, in one part cutting off both these limestones a little below the surface, and even elevating the Wenlock rocks on the east to opposition with the Ludlow strata on the west. The dotted lines represent the position of the strata prior to the operation of the fault.



observed fact), the additional peculiarity of reversed dip in the northern sections is easily understood.

Finally, on the Silurian and Old Red rocks, worn down to a nearly horizontal surface, the coal and the conglomerates were accumulated by subsequent operations. The eastern anticlinal axis, with its fault, expires (or is concealed) under the conglomerate of Woodbury, on the north; but the western one continues, and makes the double ridge of reversed Aymestry rock in the Wallsgrove Hills. This double ridge comes to a sudden termination against the road which leads from the Hundred House, south of Abberley Lodge, toward Bromyard.

Here is a remarkable quarry of Upper Ludlow beds on a strike to the N. 40° E., with a curved dip to the south-east of 75° and 80°, the strata arching over toward the north-west. The quarry exhibits itself to the spectator looking southward; but, for convenience of comparison with the other drawings, the section is constructed in reverse, as if it were seen to the northward.

a Beds of shale, with *Lingula Lewisii*, *Terebratula Wilsoni*, *Euomphalus coronatus*.

b Three beds 10½ feet thick. Near *a* occurs *Atrypa prisca*; near *c*, *Terebratula navicula*.

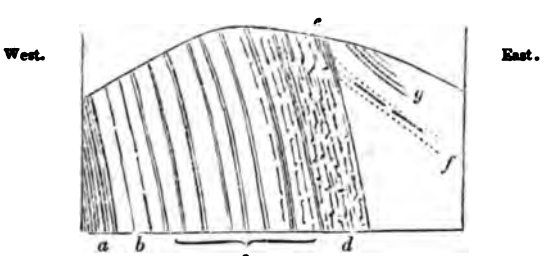
c Series of beds 31½ feet thick, with six partings or way-boards of "Walker earth."* At the beds *b* and *c* are hard laminated beds, involving a certain nodular structure. The layers of walker earth are, excepting one, which is a foot thick, merely partings. They are at intervals of 3½ to 6 feet apart.

d Beds of compacted balls 12 feet thick.

e Thin red micaceous shales. The other beds seen to the eastward are detached, and dip at an angle of 80° towards the south-east.

f Gray micaceous sandstone, of the Old Red Series, very near the bottom, with a species of *Lingula*, which has been found in it elsewhere, and peculiar bands o. carbonaceous matter, scarcely to be called coal, but probably *reliquiæ* of plants.

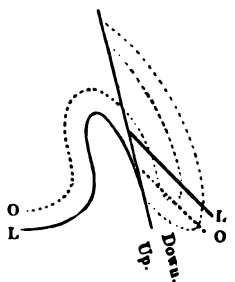
g Are upper Ludlow shales, in actual position *above* the Old Red beds *f*, and full of the usual fossils which belong to beds higher in the series than any of those in the sections from *a* to *d*.



In this situation it appears that *f* and *g* are in a state of reversal; the uppermost Ludlow fossils lying above the lowest bed of the Old Red. There is also a complete unconformity of position between the beds *f*, *g*, and the beds *a*, *b*, *c*, *d*. Between these two sets of beds,

* Walker-erde (German), *i. e.*, fuller's earth.

then, a fault must be conceived to pass. If, according to the indication of the red shale *e*, we suppose the beds *a*, *b*, *c*, *d* to be in series ascending eastward, so that *d* is the most recent, the theoretical explanation of this uncommon case may be according to the subjoined diagram, representing a vertical section.



O and L represent beds of the Old Red, and of the Ludlow formations, bent, reflexed, and broken by a fault F, so that on the eastern side of the fault L is found superior to O, and dipping at a different angle. Other hypotheses may be proposed, but they all involve as difficult conditions.

We may pause for a moment to remark the singular fact, that in the continuous ridge of Aymestry and Ludlow rock, which ranges from Hill-end to Wallsgrove, the unbroken surface of stratification, *twisted* at Hill-end, is so bent as to dip *westward* north of Hill-end* to be *vertical* near Ridge Hill, and to maintain *reversed* flexure at every point to the northward. No more remarkable example can be given of the *generality* of the pressures to which the stratification was subject in the districts under review.

In the grounds of Abberley Lodge is a singular patch of Wenlock

conglomerate, which forms a high cap to this range of the Abberleys, and, in fact, constitutes their loftiest point. This mass of conglomerate dies away on the south into the ordinary red sandstone, and on the north touches the Old Red sandstone; so that here again the Silurian rocks are (superficially) divided, but the division is not, as at Knightsford Bridge and Martley, in a depression, but on a lofty hill.

Beyond this high conglomerate summit, the Silurian ridge is suddenly bent to the south-east, and then continued in a direction quite different from, and at first rectangled to the main line of the Abberley Chain, viz., to E., E.N.E., and N.E. On its northern face the Aymestry and Ludlow rocks appear dipping N. and N.W.; on its southern edges appear at intervals, especially in the Round Hills, broken ridges of Wenlock limestone; and the whole is considerably folded, and partly fractured in lines parallel to this part of the chain.

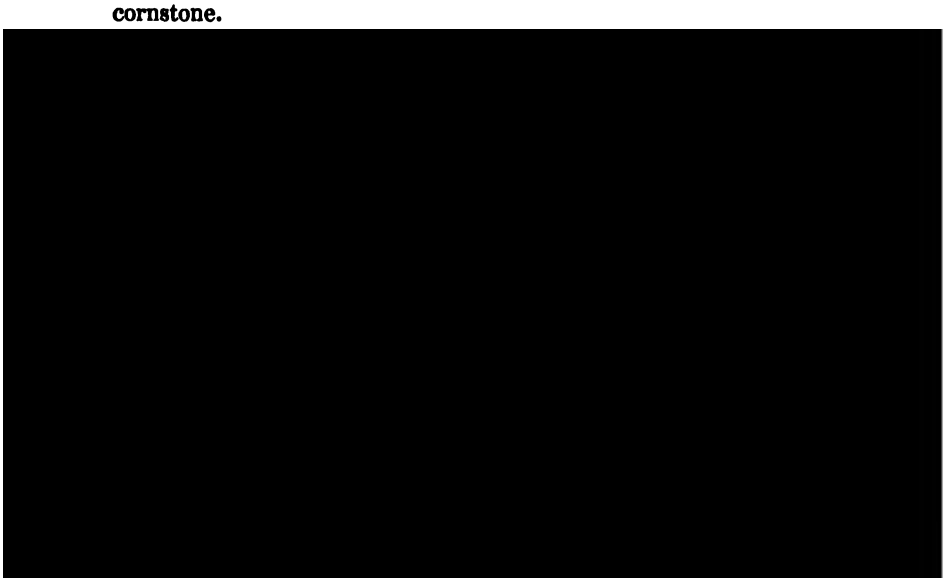
The termination of this chain, at the Round Hills, near Dick Bridge, and near Wordley Farm, is singularly abrupt. The Silurians plunge beneath the Old Red conformably (near Wordley Farm), and beneath the New Red unconformably (at and north of the Round Hills), and these two red deposits of such unequal antiquity, can be traced, in contrasted surfaces, to their junction line, for some distance north-east of the Silurian promontory. This junction line is the line of the sudden termination of Palæozoic strata, so often referred to in previous pages.

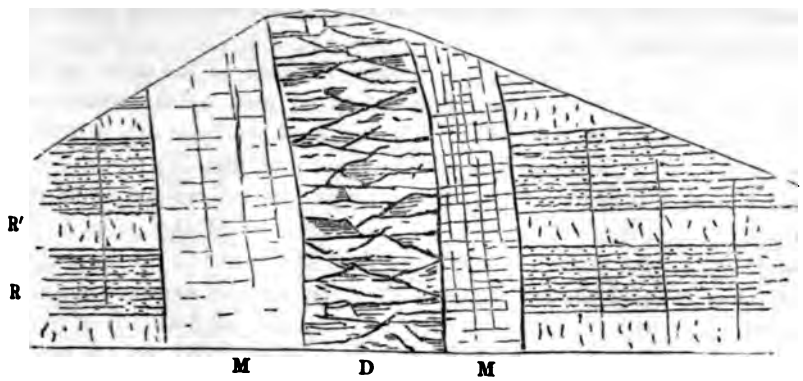
The country round the Abberley Hills, consists of the Old Red sandstone, the coal formation, and the New Red sandstone; and to each of these classes of strata belongs a peculiar character of physical geography and agricultural appropriation. On the west, the Old Red sandstone appears in long ridges and hollows, and in rows of dome-shaped hills, which, near the Abberley Chain, are situated on lines parallel to its general direction. This extensive surface of fertile land is richly wooded on many of the slopes, and full of flourishing hop-yards and orchards in the valleys. The coal formation appears only on the north and north-west quarter; and there occurs in a flatter and less wooded, less picturesque, and less fertile surface; while on the east spread the wide depressed plains of New Red formation, mostly arenaceous near the Abberley Hills, and on that account (as in the Ryeland district, near Newent), much cultivated for barley.

In only one situation, at Brock Hill on the Teme, north of Shelsley Beauchamp, is any trap rock visible, except on the direct line of the Abberley Hills. This trap constitutes a remarkable dyke, which crosses the Old Red Sandstone, in a line directed nearly 10° north of west and south of east, having its sides a little arched, with a slight dip to the south. Its substance is a dark, large-grained greenstone, occasionally becoming syenitic by the reddening of the felspar, and the pre-

sence of some quartz; but upon the whole corresponding much with the rock called "jewstone" (or rather ddu, i. e., *black stone?*), on the

Clee Hills. It is unlike any one of the many varieties of syenite in the Malvern Hills. In general structure it is not columnar but tabular; the floors of rock lying right across the dyke, and dipping eastward about 60°. The width of the dyke is 30 feet. The strata here divided consist of red sandstone, laminated and micaceous, in thick beds, alternating with thick beds of red marl, mottled with greenish and whitish spots and elongated patches. the usual appearance of the sub-calcareous marls, which enclose nodules, approaching to the nature of cornstone.





R. The Old Red Sandstone.
R'. Marl beds of ditto.
M M'. Altered or metamorphic strata.
D. The dyke of trap.

In regarding the *structures* of the stratified rocks, we observe that, on approaching toward the dyke, the stratification grows less distinct, and suddenly becomes untraceable; that, instead of it, especially on the south side, a great abundance of angularly intersecting divisional planes occurs, so as to produce prismatic structures perpendicular to the plane of the dyke. Further, we observe, parallel to the dyke, to a distance of 30 or more feet from it, several long very straight, nearly vertical, joints, continuous through all the beds, without any sign of vertical displacement, or any mark of lateral disturbance, unless the appearance of broad striation or narrow fluting, which horizontally marks the vertical sandstone surface, 30 feet from the dyke on the north side, be of the nature of slickenside, and referrible to lateral movement.

Near to the dyke smaller vertical fissures are rather numerous; but it is only at intervals of several feet that the long continuous joints are to be observed. Vertical fissures are not remarkable in the dyke itself.

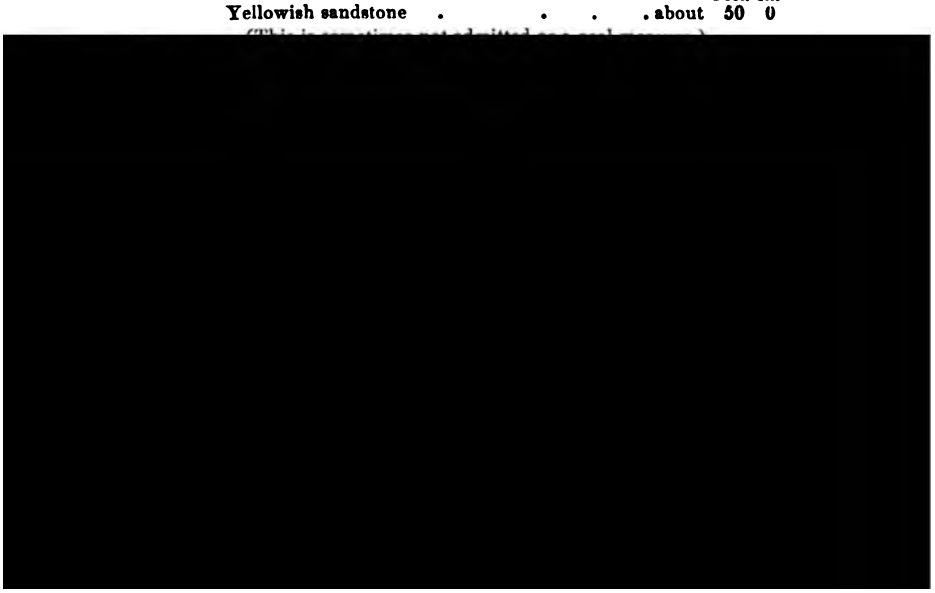
In respect of the *texture* of the stratified rocks, we find it greatly changed near the dyke, and the change is accompanied by mineral alterations and re-arrangements, which deserve particular attention. The laminated textures of the sandstones disappear; the mica which covered the laminar surfaces vanishes, the colour is altered, and the stone becomes a uniform or fine grained, or compact rock, easy to be mistaken for genuine trap. The marls lose their red colour, and become dark, or black and hard, except the green or whitish spots in them, which acquire consistence, rather than hardness, and assume a concretionary aspect approaching to crystallization. Specimens may be

selected of those pseudo-amygdaloids and pseudo-porphyries, which are extremely interesting.*

On inspecting carefully the divisional surfaces of the dyke, we find all the joints in it lined by a thin exfoliated part, which extends over all the periphery of the blocks. The sides of the dyke are in contact with the strata, but easily separable therefrom, and the vertical surfaces of rock thus exposed are found to be very uneven and *undulated*, thus contrasting strongly with the *plane* surfaces of the joints in the same rocks, at a distance of 30 feet from the dyke. This unevenness of the surface of contact between the dyke and the stratified mass, is due to the unequal contraction of the latter, composed as it is of alternating arenaceous and argillaceous bands. The dyke and the metamorphic bands on each side are equally used as road materials.

North-west of the highest point of the Abberley Hills, and only removed from their Silurian edge about a quarter of a mile, is a nearly horizontal coal field, resting on Old Red Sandstone, which has been penetrated in experimental borings through the coal strata. The beds of coal which are here worked, form evidently a part of the group which spreads over some extent of the Forest of Were, and thus becomes connected on the one hand with the rich mining district of Coalbrook Dale, and on the other with the detached and elevated coal basins of the Clee Hills. The coal strata seen at the surface in the vicinity of the Abberley Hills are principally dark shales, with some white or yellowish sandstone not unsuitable for building. The sections, as far as they have been collected, present considerable general analogies in all the localities, and furnish sufficient means of comparison with the neighbouring districts. In the pits at Poolhouses and Mamble, now in work, we find the following series of beds:—

	Thickness. Feet.	In.
Yellowish sandstone . . . . about	50	0



	Thickness. Feet.	In.
IV. Coal (hard coal)	2	6
Hard poundstone below.		
(The borings made at Mamble show no more coal below, though continued into the Old Red marls.)		

In these collieries the beds are subject to faults ("drop down," and "jump up") and to a singular accident of flexure, whereby the bed is bent on itself so as to be doubled. In this case, the part so bent is crushed, the parts near to it remain hard and bright. This "double" runs across the faces of the coal which here strike N.N.W.

Four beds of coal are mentioned by Sir R. I. Murchison, at Lower Harcott, near Kinlet Park,* and the manner in which they are associated with ironstone, shows them to be the same group as the foregoing:

	Thickness. Feet.	In.
Coal	3	0
Clod and ironstone	3	0
Coal	1	6
Clods and ironstone	3	6
Coal	1 ft. 6 in. to 4	0
Shale, &c.	2	0
Coal	2	0

These coals are extensions southward from those of Billingsley, concerning which the manuscripts of Dr. Smith (who examined this district in 1805), yield the following section:

	Thickness. Feet.	In.	
Sinkings	105	0	
Sulphur Coal	3	0	
(This is not found near Abberley.)			
Sinkings	120	0	
Ironstone	2	6	
Sinkings	30	0	
Sweet Coal	3	0	
Sinkings	9	0	(These correspond to the Harcott and Abberley beds.)
Four Foot Coal	4	0	
Sinkings	1	6	
Two Foot Coal	2	0	

From the sections of the Clee Hill collieries, it appears they are established in the same group of beds. Taken generally, we find in the Knowlsbury section:

	Thickness. Feet.	In.
Measures with Pinny ironstone	17	0
Flams (a bad coal)	0	9
Measures, with ironstone at the bottom	166	0
Flam	6	6

* Silurian System, p. 132.

	Thickness. Feet.	In.
Measures, with ironstone at the bottom	95	0
Flam (a bad coal)	1	6
Measures	232	6
Great Coal	7	0
Three-quarter ironstone measures	3	6
Three-quarter Coal	2	9
Clumpers and ironstone	10	0
Smiths' Coal	4	0
Measures	27	2
Four Foot Coal	3	6
Measures	47	7

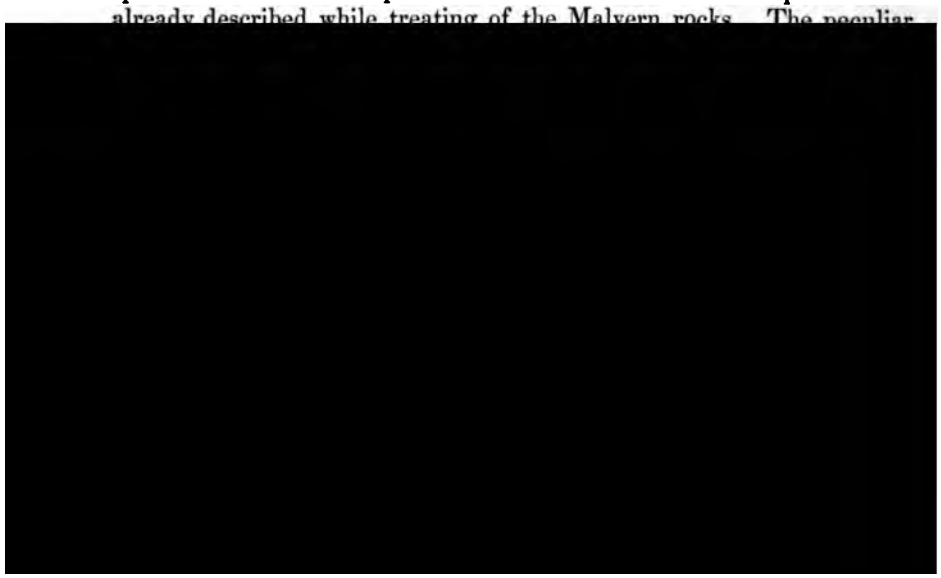
The corresponding measures are thinner in the Cornbrook section; in which the interval between the Smith's coal and the Fourfoot coal is only nine feet. The three-quarter coal is not mentioned at Cornbrook.*

The connexion is thus completed of the mere *line* of coal in the Abberley Hills, with the productive beds of the Forest of Were, the Clee Hills, and Coalbrook Dale; it has already appeared that in the district south of the Malvern Hills the outcrops of coal which occur have a similar affinity to the productive districts of the Forest of Dean and Kingswood. These various and probably wasted outcrops of coal —wasted before the age of the New Red Sandstone—are, perhaps, an indication that more extensive deposits exist uninjured beneath that Red Sandstone further to the east.

No mineral vein has been observed in the Abberley Hills.

MESOZOIC STRATA OF THE ABBERLEY DISTRICT.

The New Red Sandstone formation of the Abberley district corresponds with the lower parts of the richer and more complete series already described while treating of the Malvern rocks. The peculiar



section appears, showing in the west, at the bottom (200 feet above the sea), this peculiar conglomerate. It dips to the east, and is in this direction covered by the ordinary New Red Sandstone, full of oblique laminations, which on the average dip also to the eastward, (some layers are horizontal, but there is not one case of their dipping to the west). Above these is a series of red and pale clays, so much contorted and displaced as to indicate considerable movement, by fault or sliding since the data of the deposition of the red marl. The conglomerate rises (by a transverse fault?) just north of this to the summit of Rosemary Rock, 378 feet above the sea.

In this rock the fragments (mostly trappean) are of all sizes below one foot in diameter, (very rarely exceeding two feet); of all forms, generally worn at the edges and angles; and mingled in confusion. Near the north-eastern end, the bedded structure is rude but distinct, dipping to the E.S.E. 40°. Here is much calcareous spar enveloping the fragments. Below this part of the rock, shales, with limestone bands and balls (apparently Wenlock shales) occur for a length of 100 yards.

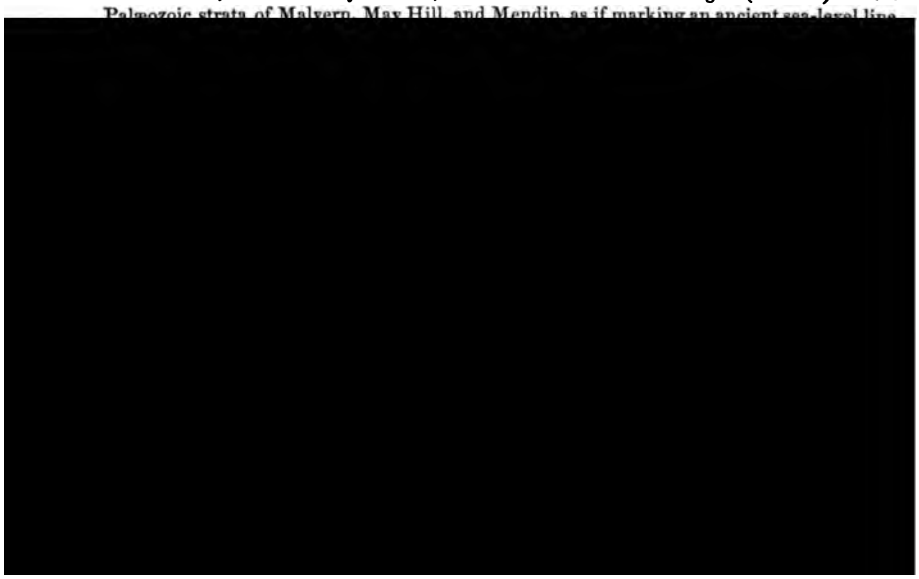
North of the Teme, the conglomerate, partly interstratified with Red Sandstone, makes a continuous narrow range by Dean's Wood and Collin's Green, where it occupies for a short space the depressed summit of the hill near the transverse fault, (diagram p. 149). After skirting the eastern slope of the hill, one third of a mile, it crosses the summit in a line to the north-west, between the Silurians and New Red Sandstone.

About Tinker's Hill, in the road, the conglomerate (though pebbly) has a trappoid aspect. The little woody ridge beyond is continued as a buttress of Berrow Hill. Here it is excavated, and otherwise much exposed, and is certainly conglomeritic. About the Old Pit heaps, and other slighter but frequent exposures in Berrow Hill, only conglomeritic detritus appears. The fragments are subangular, worn, or rounded, and are mostly trappean; but fragments of Old Red Sandstone may be recognised. As already mentioned, it is separated from the old red by a thin band of coal and shale, yielding feeble springs of water. A little north of Berrow Farm it ceases for above three miles, and is replaced against the Silurian edge by Red Sandstone, (abundant about Martley), and red marls. The Red Sandstone at Martley is traversed by small faults which may be counted in the road cutting west of the village, to the number of nine, of which, seven slope much to the east, and follow the ordinary law, (mentioned p. 141), by depressing the beds in that direction; two are nearly vertical, one depressing, and the other elevating to the east. (See the diagram, p. 151).

Woodbury Hill, a mass of the same conglomerate as Berrow Hill,

(New Red Sandstone beds are visible in the central part), is only separated from the Silurian strata below by a coal outcrop. The little hill called Round Robin is of the same nature as Woodbury. In these hills there is no deep excavation, but many shallow exposures of loosened conglomeritic masses. Among the fragments loose on the surface was a piece of fossiliferous Caradoc sandstone; but nearly all the stones are trappean, subangular, and worn in various degrees. In the Hills over Abberley, it also rests on Silurian, and lies against the south-eastern slopes and edges of these rocks, from the Hundred House to beyond Ramscomb Copse. In these hills it is sufficiently exposed in natural hollows and artificial excavations to leave no doubt of the conglomeritic character of the mass. Close by the road from the Hundred House it is rudely bedded, the inclination being to the S.E. Above the narrow lane leading toward the village of Abberley, an excavation carried 80 feet into the hill shows a variety of trappoid and arenaceous stones, with some Wenlock limestone, roughly aggregated, and but slightly consolidated. The stones are subangular, but worn on the prominent parts. Similar observations may be made near Ramscomb Copse.*

* Sir R. Murchison has inferred, from the abundance of angular pieces of peculiar trap about Berrow, Woodbury, and the Abberley summit, that these hills contain *unseen* centres of pyrogenous rock; and his remarks on this subject are the more interesting because he unites in the same general view the similar masses of the Clent, Stagshaw, and Church hills. As, however, the superficial parts of the hills first named exhibit only recomposite masses, full of angular, subangular, and rounded fragments, while it is *not certain* that they conceal a rocky nucleus different from that reaggregated mass which forms the heart of Rosemary Hill, it is obviously necessary in our representations and descriptions of these hills to exhibit the determinate analogy which they offer with the several masses of Haffield conglomerate, whose trappoid aspect and geographical relations to the Palæozoic and Mesozoic strata are the same. The precise circumstances of the formation of these hills cannot be properly discussed without the evidence bearing on the same point, which may be gathered in the country north of the Abberley region. It is remarkable that the Clent, Church Hill, and Abberley summit, rise to about the same height (1000 ft.) as the Palæozoic strata of Malvern, Max Hill, and Mendip, as if marking an ancient sea-level line.



GENERAL COMPARISON OF THE ABBERLEY AND MALVERN HILLS.

Compared with the district of Malvern, the Abberley Hills offer so complete a similarity in the characters of their stratification, so far as these are visible, as to leave no doubt of the former continuity of the deposits. They were doubtless accumulated in the same oceanic basin, and the long subsidence already established in the one case must be admitted in the other. In respect of the distribution of organic life, only very slight differences can be pointed out. The whole of the upper Silurian series of Abberley, is perhaps, rather poorer in fossils than in the country of Ledbury; and certain forms occur in it, as *Pentamerus Knightii*, which are not yet found in the Malvern region, but these local peculiarities do not effect the inference above stated. There is, however, a point of view in which the group of the Abberley Hills differs greatly from the chain of the Malverns. It is broken into several portions, not merely to the eye, but by actual structural division; the New Red Sandstone and old red formations meeting over the sunken Silurian beds. Moreover, in the country adjoining the Syenite of Malvern, the strata are much bent, but hardly broken by faults. In the Abberley country, faults as well as flexures abound. Finally, Syenite is seen at only one point of the northern range, while it makes the great feature of the southern mass.

Now all these differences appear to depend upon one circumstance: the *inferior amount of vertical movement* to which the Abberley region has been subject. If the point of Syenite in it be compared with the summit of the Worcestershire Beacon, the difference of elevation is 1034 feet, but the highest point of the Abberley Silurians, 880 feet, is only 64 feet below the summit of the Malvern Silurians, 944 feet.

If both districts were again covered by water, and the northern one raised out of it, to the full height of the southern, it appears probable, that over one long anticlinal of the Syenite, the Silurian strata which now cover it would have been removed from all the summits, so that the syenite might have been continuous at the surface with that of Malvern, except at particular depressions, like the Silurian pass near the Hereford Beacon.

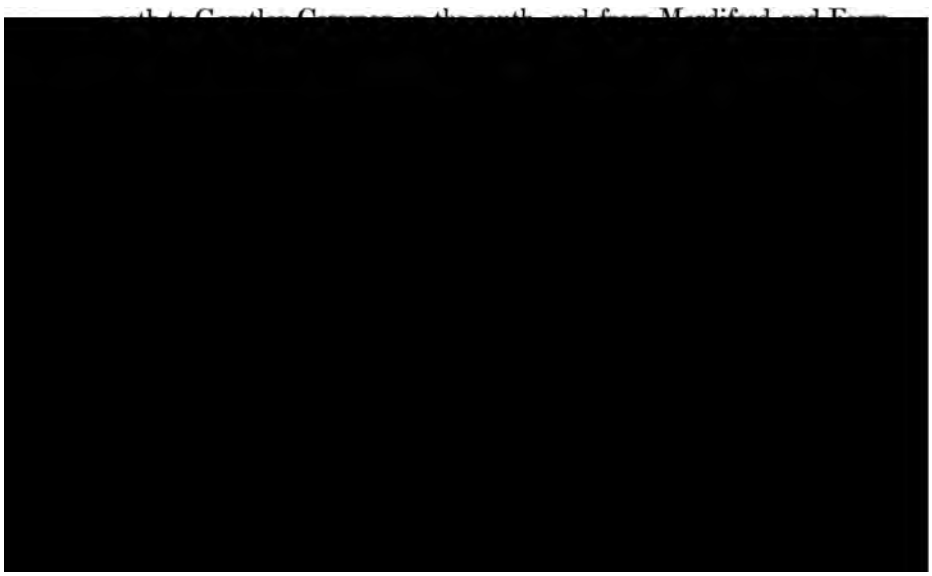
By this denudation, the principal signs of fracture in the upraised Silurian beds would have been removed; for these must abound most above the irregular basis of Syenite, whose extensibility is so different from that of the shaly Silurians; and by an inverse application of the argument, we may be assured that were the Malvern Hills, so unequal in height and in breadth, now covered with the Silurians which still in

places overlap them, many faults both longitudinal and transverse would appear among their inequalities. We may, therefore, taking into account the existing partial continuity of the masses, admit the elevation of the Abberley Hills to be due to the *same system of movements* as that which displaced the Malvern Syenites; and be prepared to expect evidence of its extension to other districts.

It is interesting to stand in the valley of the Teme, near Knightsford Bridge, and view on the north the bare Caradoc hills, on the south Upper Ludlow rocks covered with wood, on the west Old Red Sandstone, on the east New Red conglomerate, while beneath our feet are the sediments of the modern river. The interval between the Caradoc and the Ludlow rocks is marked out by two faults, depressing the strata there; and, from general considerations, it is presumable that these faults are of so ancient a date that they divided the Silurian ridge, and gave passage to the water of the sea, perhaps to a tide river, before the accumulation of the New Red conglomerates, which in fact, were the littoral deposits of the period. Perhaps, when the sea deserted that ancient channel, and the western region became dry land, a river followed the course which had been marked out by the erosive action of the tidal current; and it may be no vain dream which beholds in the actual Teme, the lineal descendant of the primæval river.

THE WOOLHOPE DISTRICT.

Due west of the Silurian rocks of Ledbury and the syenites of Malvern, and separated from them by the broad vale of the Leadon, is the hilly and woody district surrounding the village of Woolhope. To a part of this the title of Woolhope Forest is applied, and it is convenient, for the purpose of geological description, to include in the Woolhope district the whole Silurian area which stretches from Stoke Edith on the



part in the north into a long, narrow, much lower ridge toward the south. The whole has thus the outline of a pear; and both its general figure, and all the peculiarities of its physical geography, are in striking harmony with its internal structure.

For a certain space on the north-west the Frome and the Wye margin rather closely the Woolhope district, which, being a summit or rather local centre of drainage, sends streams in every direction outwards. The principal of these, as Pentelow Brook, and the rills of Fownhope and Soller's Hope, gather waters from the central dome, and cut through the surrounding ridges in deep and romantic glens; but these ridges are in general little broken, except by inequalities of elevation. One may walk on the exterior crest of hill by a continuous high path, which runs uninterrupted to the east and the west, from the old camp on Ridge Hill, near Much Marcle, by Marcle Hill, Hooper's Oak, and Seager Hill, to the vicinity of Stoke Park, a distance of six miles. The inner ridge is less continuous; and on the western side of the district the frequent partial division of the woody ridges, by little depressions, gives more variety to the landscape. The valleys which intervene between the concentric ridges are remarkably smooth and even in their surface, and are not only free from foreign drift, but generally clean swept of all local detritus, a work for which the actual streams are utterly inadequate.

The relative elevations of several points in the district have been determined trigonometrically, by comparison with the summit of the Malverns, as follows:—

	Feet.	On what Authority.
Worcestershire Beacon	1444	Trigonometrical Survey.
In the exterior circle of hills.		
Seager Hill	928	Geological Survey.
Hill north of Cockshoot, near Devereux Park	859	ditto.
Part of Marcle Hill above the Wonder	750	ditto.
Ridge Hill, Old Camp	808	ditto.
Fownhope	566	ditto.
Backbury Hill Camp	767	ditto.
In the interior circle of hills.		
Devereux Park	590 to 614	ditto.
Fownhope	550	ditto.
In the central dome.		
Haugh Wood (summit)	684	ditto.

The Old Red Sandstone in the vale of Leadon is about 250 feet above the sea. The vale of the Wye, about Mordiford, 220.

The internal structure corresponds most accurately with the external configuration of the Woolhope district. The central dome is composed of the lowest strata, viz., Caradoc sandstone, overlaid by Woolhope

limestone; the concavity round it is sunk in the Wenlock shales; the inner ring of hills is formed by the outcrop of Wenlock limestone; the hollow which encircles it of the Lower Ludlow shales; and the outer chain of high ground which borders and overlooks the whole of this singular district, is an edge of Aymestry rock and Upper Ludlow flags and shales, dipping everywhere from the centre towards a wide area of the Old Red Sandstone.

Including the narrow stem of this pear-shaped district (which running out to the south-east almost unites it superficially, as it is certainly connected subterraneously, to the ridge of May Hill), the greatest length is 10½ miles, the greatest breadth 4½, the area 22 square miles. The axis of figure of the district, a line from N.N.W. to S.S.E., is in the southern part coincident with the axis of elevation; but not so in the northern part, where the ground is highest. Here the axis of the elevation is near the western border, so that the centre of the lowest stratified rocks is scarcely farther from the western edge than one-fourth of the diameter, measured from N.E. to S.W. In consequence of this circumstance the dips are very rapid toward the west, and the areas of the several strata narrow; but toward the east the inclinations are gentle and the breadths considerable.

The elevation may be described as dome-shaped in the north; this figure changing to a narrow, lengthened anticlinal ("the stem of the pear," as Sir R. I. Murchison designates it) in the south. The steep descent of the strata on the west is at several parts accelerated and rendered precipitate by the action of faults.

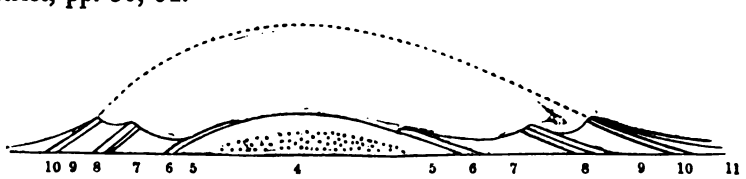
The most considerable fault in the district is one which passes from S.W. to N.E., nearly in a line from a little south of Mordiford toward Tarrington, which place it however scarcely reaches.

Its effect is to depress the strata on the north, and thus place in the line of Pentelow Brook the Wenlock limestone in opposition to the

The stratified rocks of the Woolhope district belong entirely to the Palæozoic series, and consist in a descending order of the following terms:—

Old Red Sandstone Series.		*Upper* part, conglomeritic, seen towards Ross and the Forest of Dean.
		Middle, marly and sandy part, with cornstones.
		Lower part, micaceous sandstone and marls.
Ludlow Rocks . . 955 ft.	*Upper.*	Light-coloured laminated sandstone (Downton beds).
		Gray sandy shales, and blue laminated sandstones.
		The same, with layers of flat calcareous balls and beds.
		Middle.—Aymestry rock, consisting of balls, more or less calcareous, impacted in shale, so as to constitute strong beds.
		Lower.—Gray shales, with few flat balls or beds of shelly calcareous stone in the upper part, and round, elliptical, or otherwise shaped balls in the lower part.
Wenlock Rocks. . 1307 ft.	*Upper.*	Limestone (seldom pure), partly in beds and partly a mass of calcarous balls (of limited occurrence, near Dormington).
		Shale and subcalcareous balls; these latter becoming extremely numerous in the lower part.
		Limestone, mostly a solid mass rich in coral.
		Middle.—Shale, with distant layers of balls and thin calcareous bands.
		Lower.—Limestone of Woolhope village, partly in broad solid beds, partly in masses of balls and shales, with partings, and bands of shale. It:
Caradoc Rocks . . 270+feet.		Shales and thin sandstones.
		Thin bedded compact limestone, externally much resembling the sandstone beds, and sometimes nodular, like the limestone above.
		Shales and thin sandstones.
		Sandstones and shales.
		Sandstones, conglomerates, and shales.
		(Base of the series not seen).

The features impressed by these several rocks in the Woolhope district, may be understood by reference to the following diagram, which represents a section across the district, from the river Wye, through Fownhope Park, to the vicinity of Putley, in a line nearly east and west. The numbers correspond with those employed for the Malvern district, pp. 50, 51.

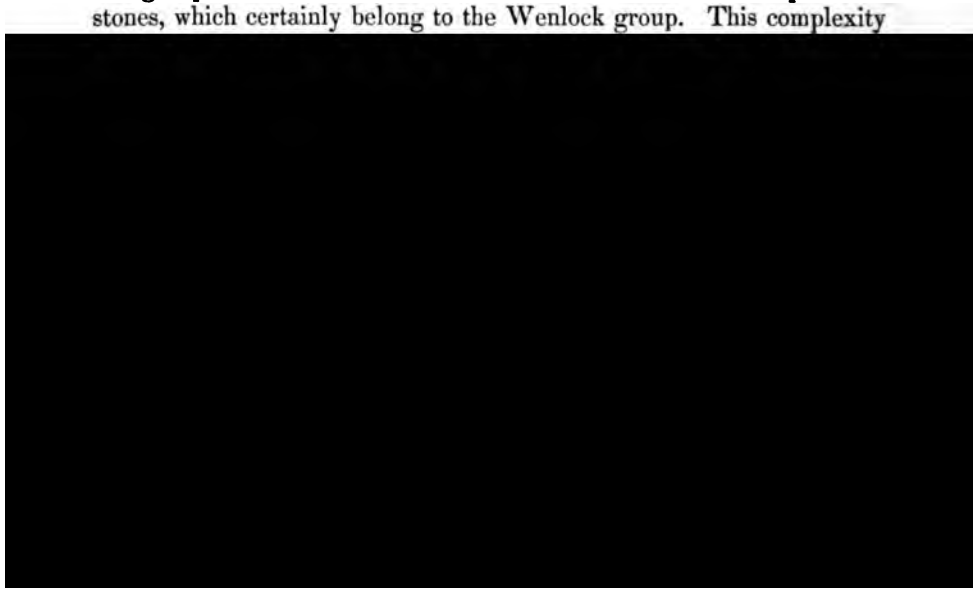


Caradoc Sandstone.—The lowest strata seen in this section are the Caradoc sandstones; and of these only the upper portion is visible. None of the purple conglomerates and sandstones of Malvern, and only slight traces of the conglomerates of May Hill, apppear in the central elliptical dome of Woolhope. This dome is mostly covered by woods,

which receive the name of Haugh (high) Wood, and rises to a height of 684 feet above the sea. Standing on this elevation, the spectator finds himself surrounded on all sides by a border of hills formed by the superior strata, and which rise in several points to a greater elevation; but in the direction of the continuation of the Woolhope axis, May Hill can be discerned, and across this direction (over a broad synclinal of Old Red Sandstone, which reaches to Ledbury,) the Chain of the Malverns.

The Caradoc sandstone is of small breadth, where cut off on the northern side by the Mordiford fault: its boundary runs in nearly a straight line from Pentelow Brook to Welcheston, and makes a slightly-undulated sweep round Broadmore Common, by Ridge Wood, to Pound and Pentelow Brook. It occupies an area of one mile and a half long from N.W. to S.W., and of three quarters of a mile broad, or about two square miles. Near Pound patches of detached and dislocated limestone lie in this area. The best sections are seen in the roads of the Haugh Wood, near Pound, and at various points about Broadmore Common; but fossils are not very abundant, because only the upper part is sufficiently exposed, and this is nowhere rich in organic remains. Strange to say, even in this unpromising country, a boring for coal has been instituted at Mangerdine, in Caradoc sandstone and shale, on the south side of the Mordiford fault.

Woolhope Limestone.—The next strata are generally of an argil laceous and calcareous type, and they are applied closely to the central sandstones, and so mixed with them, as to render a very precise separation difficult. The great bulk of the Caradoc sandstones is surmounted by some thin limestones and shales; then follows an upper series of thin sandstone and shales, which are in fact part of the Caradoc group; and above these comes the mass of the Woolhope limestones, which certainly belong to the Wenlock group. This complexity



a dip westward of 10° or 12°, to Wyla and Rudge End. Here the dips vary, and the outlines undulate, the strike being often N.; N. 50°, E.; E.; with a dip to the west, south-east and south, 15° and 20°.

Some further small disturbances appear about Westington and Hill House, and the curious narrow prolongation of this rock, south of Woolhope to Twillis, is a double ridge, of which the parts here show strikes to the N. 16° E., and 15° W., and dip westward 45° and 77°. The broad floors of this rock about Wooolhope Church have moderate dips (11°, 15°, 17°) to south-west, south, and east; and there is a small anticlinal, with dips 26° to the S. and 15° to the N. From Woolhope to the north-west, by Welcheston, Sharpridge Wood, and Joan's Hill, the strike is to the N.W., and the dip to the N.E. 18°, till we reach the Pentelow Brook, where the beds range E. and W., and dip N. 20°.

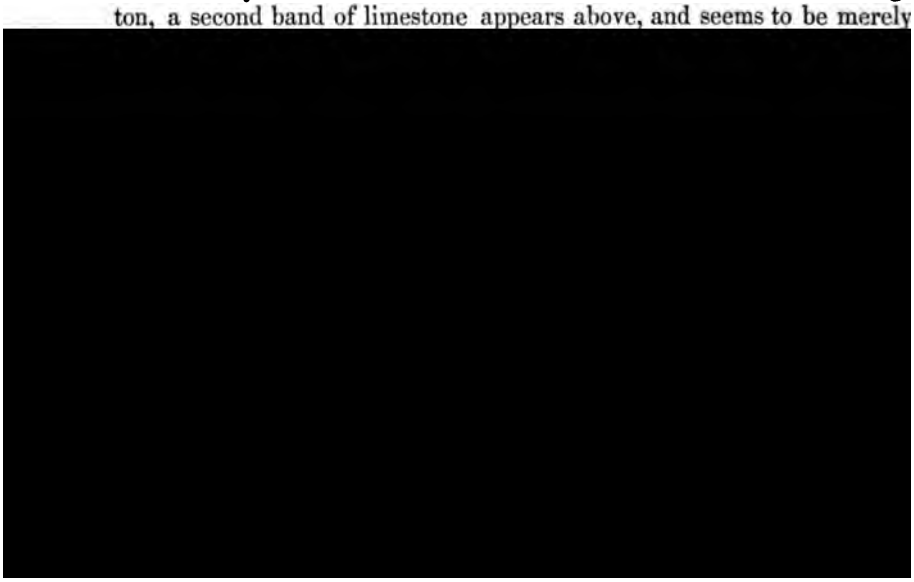
The Woolhope limestone forms the broadest calcareous zone in the district, and is quarried about Joan's Hill, Woolhope, Westington, Rudge End, and Littlehope, for walling and lime-burning. At Littlehope, on the westward dip the quarries are extensive; and the rock, in thickness, solidity, regularity, and quality, emulates the neighbouring Wenlock limestone of Fownhope, contains several of the same fossils, and by all its characters and associations, claims to be admitted into the Wenlock series, and not to be included in the Caradoc group. In no other part of the Woolhope district is it so well developed, and so valuable, as in this north-western quarter; though at Joan's Hill, at Woolhope, and in a general sense in this whole district, it is thicker, more strictly calcareous, more remarkable and important, than in any part of the districts of Abberley, Malvern, or May Hill. Hence, it may very conveniently be referred to as Woolhope limestone, a name employed for it on some occasions by Sir R. I. Murchison. In the deep quarries, where the stone retains its *earth-colour*, it is of dark, bluish-gray colour; but near the surface it varies to a light-brown or reddish-brown tint. It is usually formed in broad uneven floors, with partings of soft shale, and veins of calcareous spar, often tinted red. Beds of balls sometimes replace the solid rock, and these often contain corals like those of the Wenlock group. The lime burnt at Littlehope has the property of setting in water. Among the remarkable fossils of Littlehope quarries, are specimens of *Bumastus Barriensis*.

The Woolhope limestone is the only rock in this district which displays, even in the smallest degree, a genuine cleavage structure. This may be seen with attention in the road from Woolhope toward Broadmore Common, and in the Haugh Wood, near Joan's Hill. In the former place the imperfect cleavage is in lines directed to the E.N.E., parallel to a line of fault by Overbury and Devereux Park. In the latter instance it ranges E. and W.

The Wenlock shale forms round the central dome of Woolhope a broad, continuous, encircling concavity, marking most clearly the effects of excavation by watery forces, though not by those at present in action. This shale exhibits, especially in its lower part and below the middle, many bands of calcareous or subcalcareous nodules; thin, short, interrupted, calcareous beds also occur. The shale is mostly soft, and perishes with moisture; it is well exposed in the roads about Woolhope and Warslaw; and fossils may be collected from it at several places, especially on Checkley Common. The area which it occupies is from one quarter to three quarters of a mile in width, and about seven miles in mean length, or about four square miles and a half. It is narrowest on the western side. The valley which it forms is from 250 to 400 feet above the sea.

The Wenlock limestone succeeds, and forms an always-traceable, though discontinuous ridge round the strata already mentioned. It is broken through by many small glens in the south-eastern and south-western parts, and much interrupted and degraded by a fault in the north-west. This fault, indeed, almost destroys the appearance of the rock for a mile in length, between the houses called Cloud's and Dormington Wood. It may, however, even there be traced at intervals, and elsewhere it is very conspicuous and elevated.

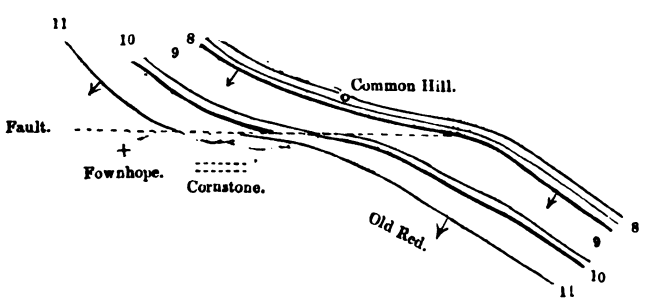
In Fownhope, the highest part of the limestone is about 550 feet above the sea, and in Devereux Park about 650 feet. In each case the rock is in the lower part solid limestone, 30 or more feet thick—in which, however, a tendency to spheroidal or concretionary structures is traceable—and this is covered by a considerable mass of subcalcareous balls, mixed with shale, and of no value for lime or building, but rich in organic remains. This series is sometimes 30 or 40 feet thick, and above it only shales and scattered balls can be traced; but at Dormington, a second band of limestone appears above, and seems to be merely



Wood, Canwood, and Winslow Mill, on the eastern side; Lindels at the southern extremity, and the Fownhope quarries on the west. There appears to be most limestone where the fossils are most plentiful.

In tracing the course of the Wenlock limestone from the fault near Mordiford, we remark many singular facts. At the end of the Fownhope ridge, layers and balls of Wenlock limestone, ranging N. 20° E. and dipping 50° W.N.W.; but following these to the summit of the ridge, their strike is found to be changed to N. 32° W. with a dip to the S.W. of 44°.

From Fownhope the strike continues to the S.E. by Nuppend, and then bends to the eastward by Common Hill toward the Lea Wood. There is some complication here by the action of a fault or sharp twist of the beds which ranges east and west, and brings Old Red with cornstone in close vicinity with different members of the Ludlow series, as in the diagram annexed. The strike to the S.E. is resumed in Lea Wood and continues through Fishpool Hill, with a dip to the S.W. of 26° and upwards.

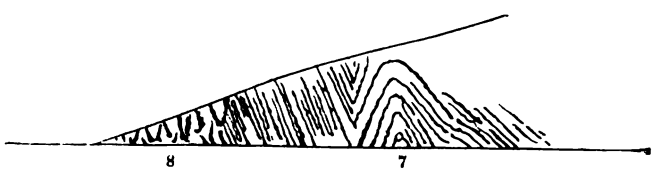


A similar circumstance happens at the village of Lower Brick Hill, the beds changing their course from N.W. to E.N.E. with a dip to S. of 50° or 60°.

A third case of this sudden twist to the east from the general strike to the S.E., is observable at Sollers Hope. The effect of these twists is a good deal of complication and interruption of the ranges of the Wenlock limestone, which, however, is traceable with care to a curious narrow point at Whittlebury where dislocation prevails, so that the Wenlock Rock is brought almost into contact with the Aymestry limestone, and finally with the Old Red marls.

Lindels is the turning point of the Wenlock limestone. From the singularly contracted and pinched ridges which are here brought close to the Old Red Sandstone, the rock expands to Whittlebury Wood, where it is largely quarried with a northward dip; then obscurely passes to the woody hills of Sapnells, which connect themselves with

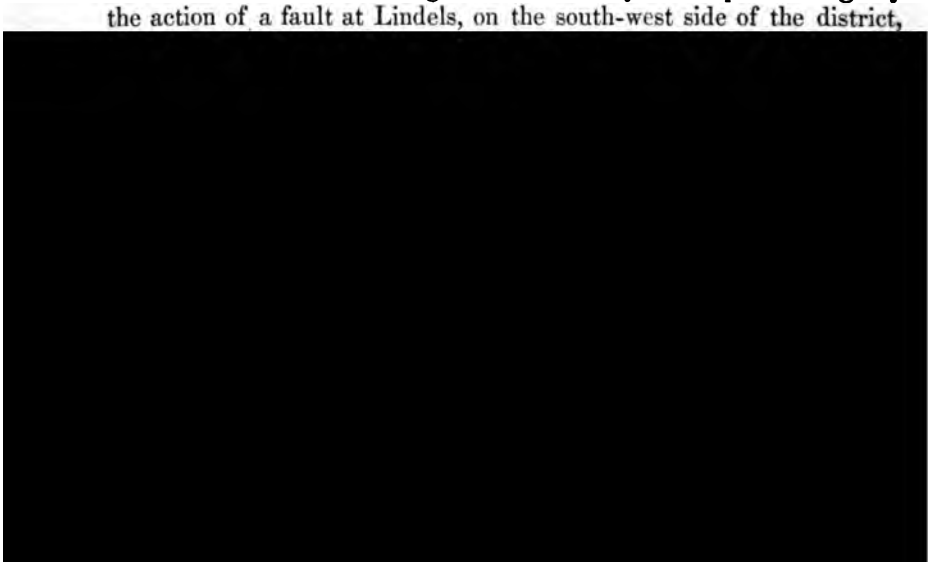
Holling Woods, and reaches Winslow Mill. The beds here are fully exposed in quarries on each side of the road with a strike to the N. or N.N.W. and a dip eastward of 26°. From this point the ridge curves more and more towards the N.W., and from Canwood to the end of Dormington Wood offers a long line of ancient and modern quarries and lime-kilns, the richest repository for fossils known in this district. The dip of the beds along this range is generally about 25° to the E. E.N.E. and N.E. On approaching the last quarries in Dormington Wood, the dip becomes 10° and 8° to the N.E., and then the beds are all turned down rather than cut off by the Mordiford fault, on a line N. 60° E., dipping N.N.W. 40° to 55°, and running south-westward in a narrow crushed ridge through the wood toward Wootton. At a gate on the road leading to Wootton the line of the Mordiford fault is crossed, and we have the following appearances.



8. Wenlock limestone crushed, and mixed with shale.
7. Wenlock shale contorted.

The Lower Ludlow shales may be studied on the south escarpment of Backbury Hill, about Wootton, and between Dormington Wood and Stoke Park. The upper parts, with flat limestones included, appear on the west side of the high ridges of Marcle Hill and Pilliard's Barn.

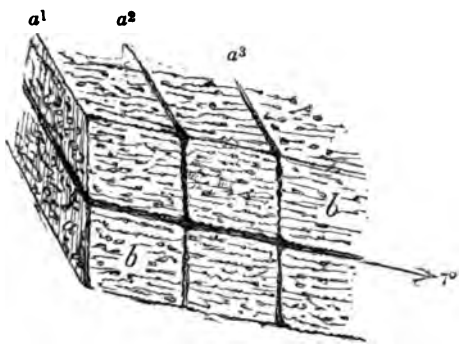
These shales appear in a continuous concave sweep on the outside of the Wenlock limestone, being nowhere entirely interrupted, though by the action of a fault at Lindels, on the south-west side of the district,



continuous range of elevated ground, the great natural boundary of the Woolhope "Valley of Elevation."

The range is indeed broken by the great fault at Mordiford, and twisted by others at Fownhope, Soller's Hope, and Lindels, but these exceptions to the completeness of the margin of the Silurian district are lost in a general view.

This rock is immediately recognised at the edge of the high ridge already noticed, by its thick beds, full of concretions, and traversed by straight cut joints. Below it and above it are thin flat shelly beds,



Joints in Aymestry Rock.
a^1. N. 10° W.; a^2 N. 9° W.; *b*. N. 87° E.; Dip East, 7°.

much more calcareous than itself, and in fact almost entirely composed of shells, especially (in the beds above) *Terebratula Wilsoni*, just as in Shropshire some beds are wholly formed of the shells of *Pentamerus Knightii*. It may even generally be said that the limestones of the Silurian system are merely the effect of rich local aggregations of organic exuviæ.

In tracing the course of this rock from Mordiford, we find it inflected on the south side of the fault, to a north-easterly course like the Wenlock limestone, to which from this point to beyond Lindels it is parallel, dipping 30°, 40°, or 50°, to the west. Its outcrop on this side of the district is about 300 yards from that of the Wenlock limestone, and its elevation is about 550 feet. Beyond Lindels it sweeps suddenly round Oldbury Camp Hill, rising to that elevated ground (808 feet), then acquiring more moderate dip (10° to 20°), and assuming a course due north to Cockshoot (750 feet), north-west to Seager Hill (928), and Stoke Park. From this point by Backbury Camp (767 feet) to Mordiford, its course (on the north side of the great east and west fault) is singularly undulated by four deep cuttings through its outcrop, which correspond with four narrow valleys issuing to the north. It is also broken by a fault, which ranges northward from Marian's Hill, by Prior's Frome, and shows a double outcrop in consequence.

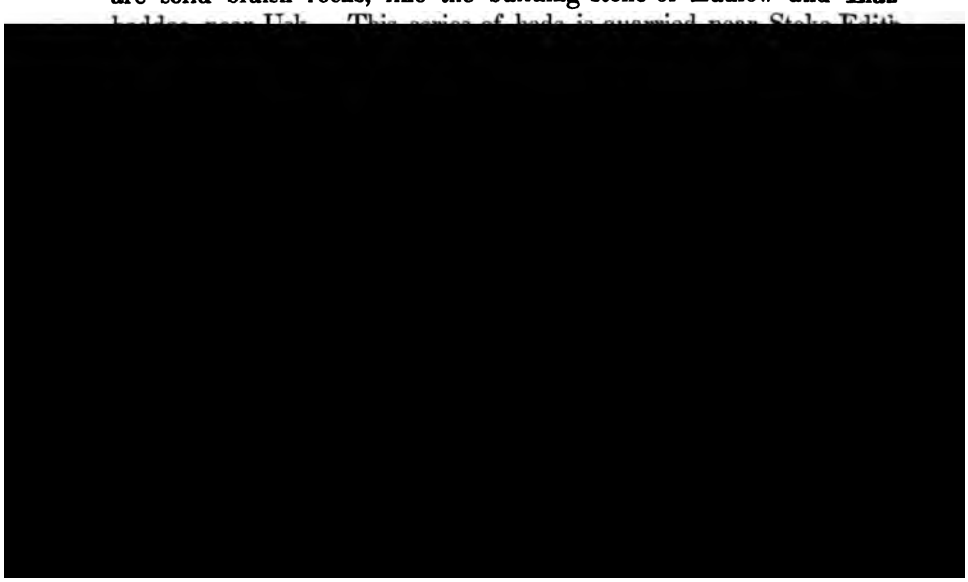
The length of the Aymestry range is about 13 miles, its breadth always below one quarter of a mile, and generally below 100 yards. Its area may be stated at about one square mile.

The Upper Ludlow shales and sandstones surround all the zones of strata which have now been mentioned, with a surface sloping outwards, from the ridge of Aymestry limestone. The slope of these strata on the east is from 5° to 12°, and on the west 20° to 30°.

The continuity of the outline is broken at Prior's Frome, Mordiford, Fownhope, Soller's Hope, and Lindels, by faults and twists, and generally speaking owing to steepness of dip (30°), and some influence of faults, its breadth is very small (200 yards) on the western side, while on the north (dipping 10 to 25°) it reaches to half a mile, on the east exceeds this breadth, and opposite Marcle in the southern part of the district measures a mile. From this point southward almost to Newent, this is the only Silurian deposit which reaches the surface, except near the Pound in Queen's Wood, where Wenlock limestone is quarried in a narrow valley. The total area of the Upper Ludlow series is about 10 square miles, or nearly one half of the whole Silurian district.

On account of proximity to the populous districts surrounding the Forests of Woolhope, this rock is traversed by many roads; and as some parts of it yield rough building-stone, and several parts materials for the roads, it is much exposed in quarries. Its mineral and organic characters thus become extremely well known, and the circumstances of its gradual transition to the Aymestry rock below and the Old Red Sandstone above are easily and frequently observable. Some of these circumstances deserve description.

As before observed, the lower beds of this series which surmount the Aymestry rock, contain thin shelly limestones. These are full of *Terebratula Wilsoni*, *Leptæna lata*, and other characteristic fossils. Above are solid bluish rocks, like the building-stone of Ludlow and Llan-



part of the Ludlow shales, and pass, almost insensibly, into the Old Red Sandstone.

These details are not to be verified on the western side of the district between Mordiford and Lindels, for there the narrow steep and twisted band of the Upper Ludlow shales is margined by detrital accumulations, which almost every where conceal the junction with the Old Red Sandstone.

Commencing our notes, then, on the north side of the Mordiford fault, we find at Old Sutton an interesting exhibition of richly fossiliferous beds, dipping to the N. 25°, with regular joints in two sets, one being N.W. and S.E. dipping 65° to N.E., and the other N. 25° E. dipping S.E. 59°. Here we have abundance of *Leptæna lata*, *Orbicula*, *Orthides*, *Cornulites*, *Serpulites*, &c. The upper beds show clearly characters of littoral deposit, and what are perhaps traces of fucoidal plants running across the strata. Sandstones with black spots cap the series.

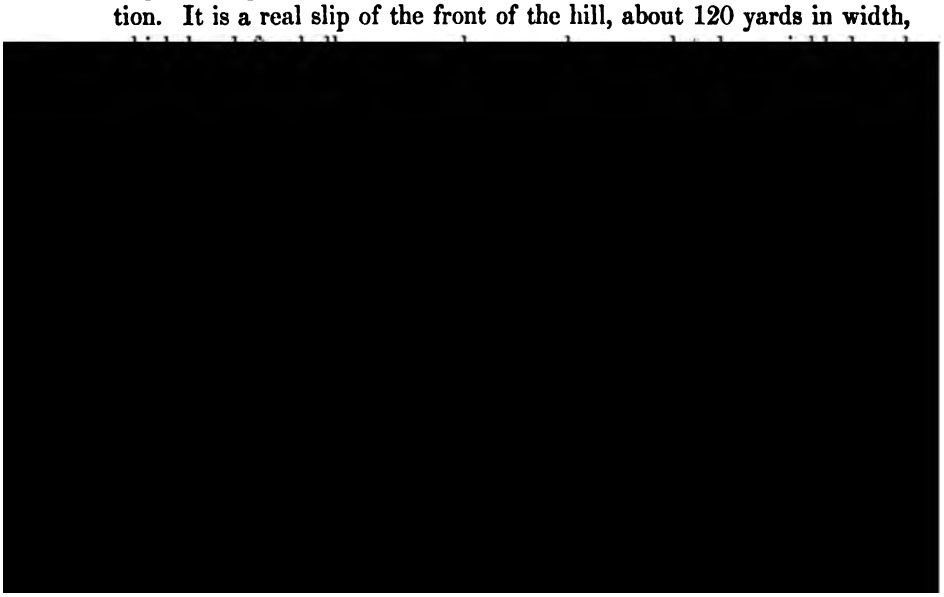
In the lane between Old Sutton and Prior's Frome, and in the short road from this to the turnpike near Larport, we find a succession of beds (dipping to the N.W. as much as 31°), of which the lowest are brown sandstones with black carbonaceous spots. These are covered by laminated sandy red shales, enclosing a band of sandstone with carbonaceous spots. Above are shales with a peculiar bed breaking in cubical fragments, and still higher are red shales and sandstones. At Prior's Frome the beds are broken through by a decided line of fault (from N. to S.), which depresses the beds on the east, with a dip to the west, that side amounting in places to 35°. (The joints range N. 30° W. dipping 57° to the N.E., and N. 20° E. dipping 57° to the S.E., while the strata strike N. and dip W. 20°). Fucoids can be traced in the beds at Prior's Frome. Wallstone is dug at Prior's Court, on a dip to the west of 46°. Between this and Dormington the beds spread out on a broad surface, with dips to the west, then north, and finally, east. About Dormington, *Leptæna lata* may be collected in great abundance with the shelly substance perfect, except that the spines of the hinge are seldom complete. At Perton, near Stoke Edith, the sides of the valley offer an intelligible section from the Aymestry limestone to the Old Red.

The Aymestry rock is seen in the sides of Tower Hill, on a strike N. 76° E. dipping N. (23°), with joints ranging N. 77° E. and N. 85° E. and dipping S. (80°). The dip varies as we descend the valley (15° to 23°), and the blue and gray Ludlow shales and sandstones occupy a considerable breadth. The uppermost bed remarkably rich in fossils, as small Gasteropods in coral, *Leptænæ*, *Orbiculæ*, *Serpulites*, and a very long and very slender crinoidal column, are covered by blue and gray

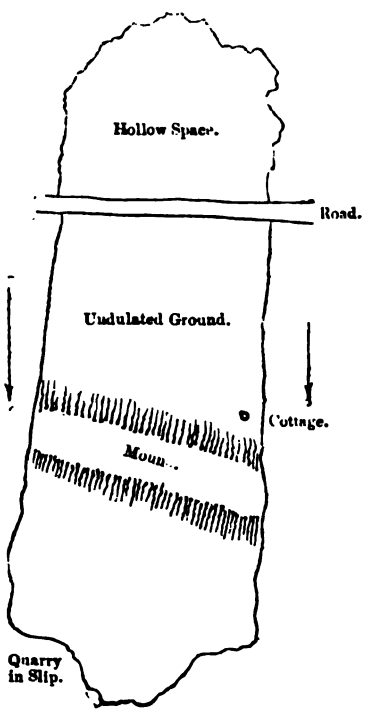
shaly and sandy layers, and thicker brown and blackish sandstones and pale shales. These beds include one or more layers full of small black carbonaceous lumps (like bufonites), and marked with various impressions like plants. Here also was found a semicircular head-plate of a trilobite. (Blackish and dark brown sandstones are often seen in the near vicinity of the Silurians, in the Ledbury, May Hill, and Abberley districts).

One of the best sections of the Upper Ludlow series may be conveniently examined in the road from Seager Hill, by Pilliard's Barn, to Hazle and Durley. On the western side, below the edge of the hill, the Aymestry rock shows its lowest part, a series of flattened calcareous nodules in shale; above are the compacted beds of balls, with distinct joints, holding *Lingula Lewisii;* then follow, imbedded in shales, many very thin beds of limestone full of shells, especially *Lingula Lewisii*, and in the upper parts *Leptæna lata.* At Hazle, the blue flaggy rock is dug, with the usual fossils, including *Cypricardiæ;* still further eastward appear laminated sandy beds and shales with Walker-earth and at length flaggy micaceous beds which are on the confines of the true Old Red series. The general dip is here towards the N.E. (10° to 20°); the ground slopes about 7° in the same direction.

Owing to the steepness and continuity of the slopes, the regular open jointing of the Upper Ludlow rocks, and the argillaceous bands ("Walker-earth") which interlaminate them in the Woolhope district, remarkable slips of ground have happened at several places. The most celebrated example is that close by the farm called, from the occurrence, "The Wonder," near Putley, which happened about 270 years since, and is noticed by many old writers.* On visiting the spot in 1842, with H. E. Strickland, Esq., we found the marks of the catastrophe still perfectly traceable, measurable, and capable of interpretation. It is a real slip of the front of the hill, about 120 yards in width,



10° S. The strata on the hill above are on a concave arch, the strike of which is nearly N., and the dip E. 25° at the crest, but only 12° or 13° where the slip happened. The joints which mostly prevail range N. 37° E. (dip 84° N.W.) and N. 65° W. There are no Walker-earth bands visible, but as Sir R. I. Murchison observes, the jointed structure, with an accidental glut of wet in winter, might sufficiently account for the occurrence. The effect of end pressure is remarkably well illustrated, by the great mound across the area, and the dislocated beds at the foot.



Great land-slips have happened on the inner face of Backbury Camp Hill, and in some other situations.

Following the line and boundary of the Silurian districts from the vicinity of this great land-slip by Wall House, Chandois, and Wolton Brook to Hom House, near Marcle, we observe, at frequent intervals, the brown and blackish sandstones, which are at the base of the Old Red Sandstone; and in crossing from this line to the elevated ridge of hills on the west the Ludlow rocks are traceable. About Chandois we find the black sandstone upon the Ludlow series; on this yellow sandstone; then red clays; then white and brown sandstones. From Much Marcle to Yatton Farm, and from Hom House to Welsh Court, are lines which

may be advantageously followed, as they cross the now narrowed Silurian district in a low anticlinal, and show its composition clearly. At Yatton Farm and Welsh Court the junction of the Silurian and Old Red beds is well exposed; at Bodenham the Aymestry limestone appears below the Upper Ludlow, which latter rock, between Lyne Down and Gamage Ford, displays a layer of many fish-bones and pebbles, in a loose blackened state, corresponding in position with the well-known "bone bed" of Ludlow. In all this part of the country the whole Upper Ludlow series is not above 50 feet thick.

The quarry at Yatton Farm shows a series of beds, the lowest being nodular and jointed like the Aymestry Rock. Above are beds about 30 feet thick, with scattered balls, and bands of soft argillaceous earth. The uppermost beds are laminated. No yellow sandstone is seen. The farm-yard is on red sandstone, which is also seen in the road banks. In the whole of the Silurian series here exposed, Upper Ludlow fossils occur; in the upper part, *Leptæna lata*, *Cypricardiæ*, *Orbicula*, and *Graptolites*; in the middle, *Terebratula Wilsoni*; and in the lower parts, *T. navicula*, and large specimens of *T. prisca*. The strike is N.N.W., and the dip W.S.W. (30° and 31°). From under Welsh Court the beds rise to the E.N.E. about 7°, and consist of the lowest bands of Old Red; the sandstones which make the passage from this to the Silurian, and hold black spots and other carbonaceous marks; and then follow the ordinary flaggy Ludlow shales full of fossils, with bands of very thin nodular limestone, as at Mathon Lodge, in the Ledbury country.

In the great quarry at Bodenham, the Upper Ludlow is excavated deep enough to display beds which correspond to the Aymestry limestone, and in these the *entamerus Knightii* was found by Captain James, R. E.

The short road between Lyne Down and Gamage Ford shows the beds of the Upper Ludlow series rich in fossils, dipping S. 16°, and covered by several feet of very thinly-bedded yellow sandstones, with partings of clay. Amidst these is the layer of black pebbly fish beds, already referred to.

It may be remarked in general that the whole of the line of boundary between the Silurian and Old Red Sandstone, on the western side of the Woolhope district, from Mordiford by Fownhope to Welsh Court, is more or less confused by faults and irregularly twisting dips, while the northern and eastern boundary is nearly free from this difficulty, from Mordiford and Dormington by Stoke and Putley to Marcle. From

north of it, the Silurians are found to dip S.W. (25°), and very near them are red clays, with cornstones. About Tedgewood the outline is determined by faults. The limestone exposed in the valley, near Pound, yields several corals, and shells of the Wenlock type. There also occur *Terebratula Wilsoni*, and *Leptæna lata*, with other indications of affinity to the Ludlow series. The extensive woods here render the complete working out of this faulted district impracticable.

In the extensive quarries of Gorstley Common the yellow sandstone, eady referred to at several points in the previous notices, becomes an ortant rock. It covers with a broad mantle the very thin repre-tatives of the usual Upper Ludlow shales, and is itself covered by black-grained beds of the Old Red Sandstone. In this district, as the Malvern region, it is certainly rather to be ranked with the rian than with the Old Red series. This conclusion is in harmony h the facts hereafter to be stated in the description of the May Hill ricts.

SHUCKNALL HILL.

This little mass of ground, removed two miles from the northern e of Woolhope Forest, but composed of the same strata, with the ie organic remains, has about the same relative value to its greater ghbour as a satellite to its primary planet, and its physical history y be regarded as similarly subordinate. The area of ground covered Shucknall Hill is above half a square mile, being one mile and an ith long, with a breadth varying from three-fourths to three-eighths. e axis of figure runs nearly north-east, parallel to the south-eastern e, but the directions of the beds correspond to this line only for rt lengths, and then sweep out of it to assume bearings N. N.N.W., even N. 55° W. (This last direction occurs at Ecknell Copse, r Westhide.) The dips are everywhere outwards. Near Shucknall m they correspond to the prominent end of the hill. Similarly on east end of the hill the dip (23° to 37°) is always conformed to the p hill slope, and to the outline of the Old Red, which environs the rian rocks; and the same is the case on the N. N.W. sides, though outline is more sinuous and the beds are more dislocated. (Dip 23° 5° at the hill edge, sinking under the micaceous Old Red.)

The hill is thus found to be an intumescence from a Red Sandstone n, more limited than any other we have yet surveyed, and in a dif-nt direction from them. The figure is anything but regular in lity, though in appearance it is somewhat elliptical. It is, in fact, a high shoe set edgeways, the sole toward Woolhope, and the in-al ridges and hollows of the strata are not inaptly comparable to irregular plications of the leather. Such a figure of elevated strata y rather be ascribed to coincident pressures in various directions, n to one simple expansive action from below.

The lowest strata exposed in Shucknall Hill are the beds of the Aymestry limestone series, which are traceable obliquely across the hill, in a curve convex to the eastward. In the great quarry their strike is S. 10° W., or in the direction of Fownhope, with a dip eastward of 46°. Further on their course to the northward, the strike changes to S.S.E., with a dip eastward of 35°. Between this main ridge and the eastern edge the same rocks are less plainly exposed, in undulations running N.N.W. There is a sign of *cleavage* in the northern part of the great quarry of Shucknall Hill, its direction east and west.

Bartestree Dyke.—The only case of pyrogenous rock which occurs near to the Woolhope district is very well described by Sir R. I. Murchison, under the above title.—(Sil. Syst., p. 185.) The direction of the dyke is from W.S.W. to E.N.E.; its width 20 feet and upwards; it is nearly vertical, while the strata which it divides are almost horizontal. These strata belong to the marly parts of the Old Red Sandstone, which abound in cornstone bands, and the alterations and induration which these have undergone near the trap, are very similar to those already mentioned while speaking of the Brockhill dyke.—(p. 157.) "The purple amygdaloid, with kernels and nests of yellowish calcareous spar forming the outer coat of the greenstone, is demonstrably nothing more than the spotted marls, so altered by the action of heat, that they resemble trappean amygdaloids. The effect of these alterations is seen to penetrate beyond the amygdaloid several feet into the adjoining beds. At a few yards from the wall of the dyke the strata of Old Red Sandstone resume their ordinary characters."—(Sil. Syst., p. 186.)

The substance of the dyke is a granular greenstone, in which hornblende predominates over the felspar and olivine. In places it is full of a small spheroidal concretionary structure. A rude prismatic structure, on a large scale, may be traced, as at Brockhill, the prisms lying across the plane of the dyke; and this structure partly enters the bordering rocks, and confuses their stratification near the dyke. Upon the whole

MAY HILL DISTRICT.

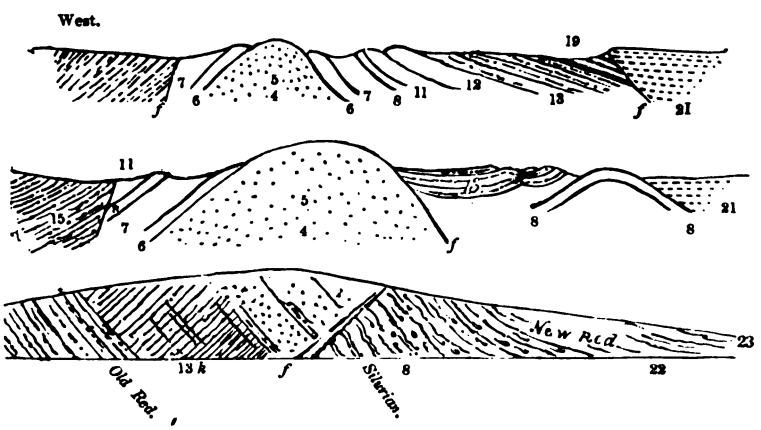
From the summit of Yartleton, or May Hill, the observer (elevated 972 feet above the sea) looks to the N.N.W., and sees the dome of Woolhope Forest in the line of the axis of the hill on which he stands; to the N.N.E. he remarks the Malvern hills beyond a great line of fracture and unconformity of the strata, with outcrops of coal; between these two lines is the synclinal of Ledbury, filled with Old Red Sandstone. Turning to the S., the eye follows the group of hills, gradually contracted by the nearer and nearer approach of the limiting Old and New Red rocks, till at Flaxley the May Hill ridge expires, acuminated to a fine calcareous wedge between two converging lines of unconformed strata, whose effect continues beyond.

May Hill thus appears like a stem, bearing the two branches of Malvern and Woolhope.

Considered geologically, the stratifications of May Hill are elevated on an axis passing N.N.W. and S.S.E.; but the geographical area covered by these rocks is longest in a direction from N. to S. The oblique upheaval of the strata has given the great physical feature of the district, but the boundary is much dependent on lines of fault.

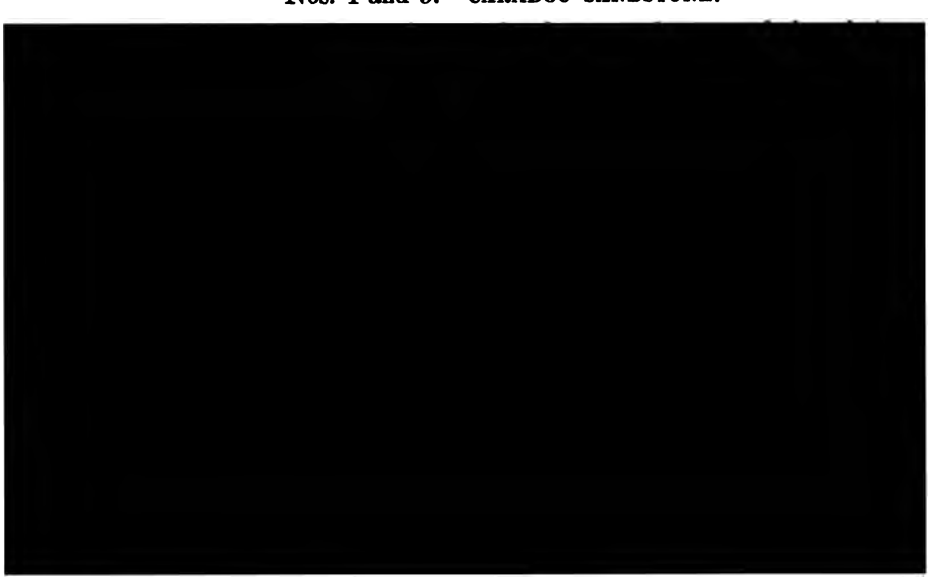
No example of igneous rock occurs in the whole extent, nor any other trace of intense action of heat, except what the disturbances of the strata offer. These consist, independently of the general anticlinal axis of elevation, of one great and rather complicated line of fracture

and erosion on the eastern side, continuous with the great fracture on the eastern side of the Malvern range, and similarly suppressing the strata on the east. To these we may add one or more transverse faults, and short dislocations on the eastern side, which further interrupt the continuity of the Silurian strata, and give to their distribution, especially in the northern part of the district, an irregularity very unusual, and, though intelligible on the map, not capable of a clear description. The following three sections across this chain, from W. to E., taken in the northern, middle, and southern parts, will exhibit some of its leading peculiarities.



4, 5. Caradoc sandstone.
6. Woolhope limestone.
7. Wenlock shale.
8. Wenlock limestone.
11. Ludlow rocks.
12. Light-coloured sandstone.
13. Old red.
19. Coal formation.
21. New red.

Nos. 4 and 5.—CARADOC SANDSTONE.

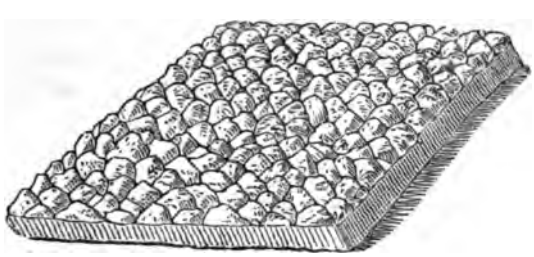


UPPER PART.—Gray shales and thin-bedded sandstones, with bands of fossils, especially in the beds which occur about 50 or 100 feet deep in the series.

It is worthy of remark, that throughout the Caradoc districts the fossils which occur in the thin-bedded sandstones neither lie on the top nor at the bottom of the slabs, but in some intermediate part, most frequently near the bottom, as if the materials of each bed, shells, sand, and all, were drifted together, and together deposited, and not that the shells were quickly covered when dead, where they died, or living in the places of their usual abode. This is not observed in the Upper Ludlow sandstones.

MIDDLE PART. — The same thin-bedded sandstones, with alternations of thicker sandstones, and some shales, and here and there irregular interspersions of pebbles, occasionally indurated to solid conglomerate. In the thin-bedded sandstones of this series, occur less plentifully, and with less regularity, the same fossils as those mentioned in the upper part.

LOWER PART.—The conglomerates—full of rolled quartz, pebbles, and pieces of felspar, cemented together by finer grains, and occasionally (especially near contortions, as in the vicinity of Huntley) very much indurated. In such situations purple tints are frequent, especially in thin, apparently crushed, beds of a more argillaceous aspect, which occur amongst the conglomerates. In several places on the west side of May Hill, the upper surfaces of the conglomerate beds are very singularly undulated by small heaps of gravel, distributed with so much regularity as to suggest a fanciful analogy to a tessellated pavement. This effect of peculiar littoral or beach action may be understood by frequent contemplation of modern very flat beaches, where small pebbles and sands are separated and sorted by the variations of gently agitated shallow water.—(*See* diagram.)



This series is of considerable thickness. It is the lowest mass of rocks in May Hill, and is well exposed in the Mitchel

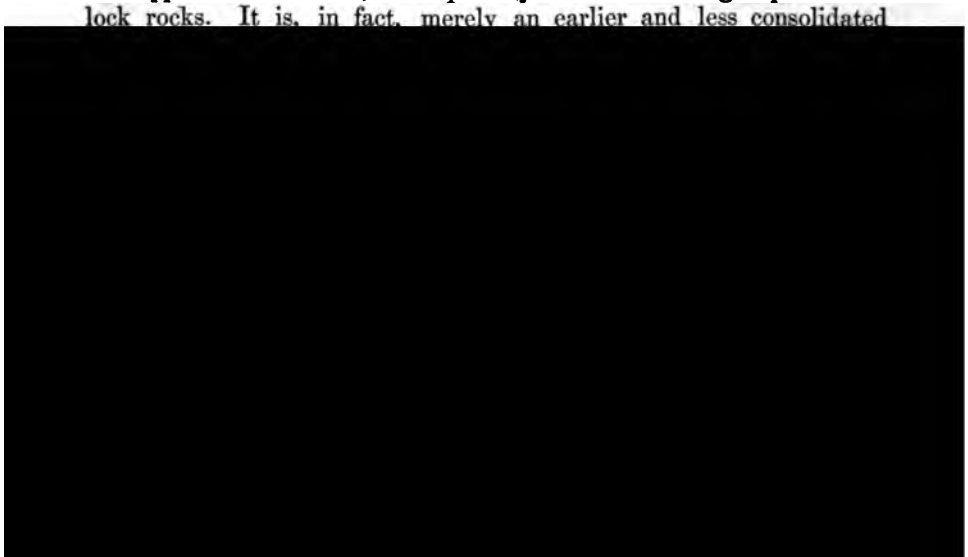
Dean and Ross roads, and in the N. E. slope of May Hill, where it is in contact (by the operation of a fault) with the uppermost member (yellow sandstone) of the Silurian series, and even with the Old Red. In the southern part of the Huntley hills it is in contact with the New Red Sandstone. No organic remains have been observed in this deposit.

The joints which pass through the Caradoc sandstone are remarkable for their regularity in the upper thin-bedded varieties, where they cross in two sets, and thus dissect the stone into a series of rhomboidal prisms oblique to the plane of stratification. On the plane of the strata these joints meet at angles of about 105° and 75°. One set of joints is perpendicular to this plane, the other inclined to it about 15°.

The Caradoc sandstones occupy a length of 3½ miles, from near Blaisdon to a point above New House, near Aston Ingham, the breadth never reaching one mile. The dips are regular only on the western side, when they generally amount to about 30°. On the eastern edge, near Huntley and near Slade, on the lines of the roads the beds are displaced, and in some places twisted and set on edge.—(*See* diagram below.)

No. 6.—WOOLHOPE LIMESTONE.

The Woolhope limestone is thicker on the slopes of May Hill than in the Malvern district; but if thicker than in some parts of Woolhope, it is not so solid or so valuable. Cut through in the lines of road from Huntley to Mitchel Dean and Ross, it shows a series of nodules and lumpy irregular beds, alternating with shale, for a considerable thickness, and makes, as in Malvern and Woolhope, a ridge of ground surrounding, and generally well distinguished in feature from, the Caradoc sandstone. It belongs, by all its characters, mineral, organic, and superficial, to the Upper Silurian rocks, and especially conforms to the group of Wenlock rocks. It is, in fact, merely an earlier and less consolidated



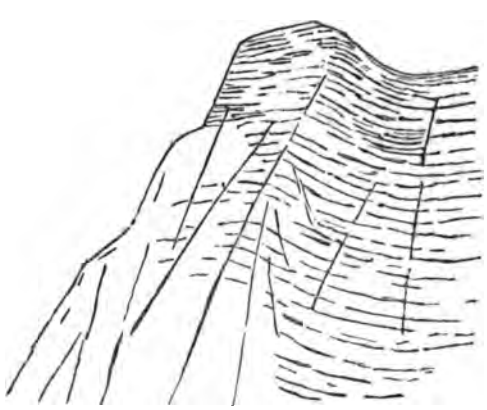
olhope limestone, the dip being westward (30°). This exhibition wed on the W. by a series of short and steep undulations, the eing in places set on edge. The analogy of the Woolhope series y Hill and Malvern is thus found to be complete.

No. 7.—WENLOCK SHALE.

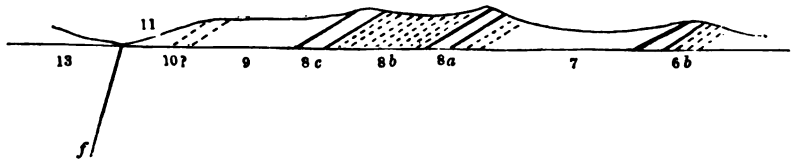
ugh but little exposed in the May Hill district, appears to be of ly uniform argillaceous basis, holding many layers of subcalca- nodules, as in the Malvern district. Hence it forms a concave between the Woolhope and Wenlock limestones. It passes ards, by easy gradations, into the Woolhope limestone. It lded but a small catalogue of fossils—a circumstance partly to its insufficient exposures. It is traceable in a course of above iles in length on the western side of the district, from near on to Aston Ingham. It is also just traceable, bending round the end of the Caradoc and Woolhope stratifications, to Clifford's

No. 8.—WENLOCK LIMESTONE.

is the grand source of lime for agricultural and building uses May Hill district, and is for these purposes extensively quarried, continuous channels, along the crests of woody hills, especially western side of the summit ridge of May Hill. In this feature strict resembles that of Ledbury, Woolhope, and Abberley. omposition of the limestone is very similar—locally rich in irregularly aggregated into very solid and compact rock, or ted into a multitude of nodular beds, with intervening soft shales. lid masses of limestone are locally termed "Woolpacks;" they he finest and most abundant lime-flour, and seem to prevail he high and prominent crests of the hills. There are generally



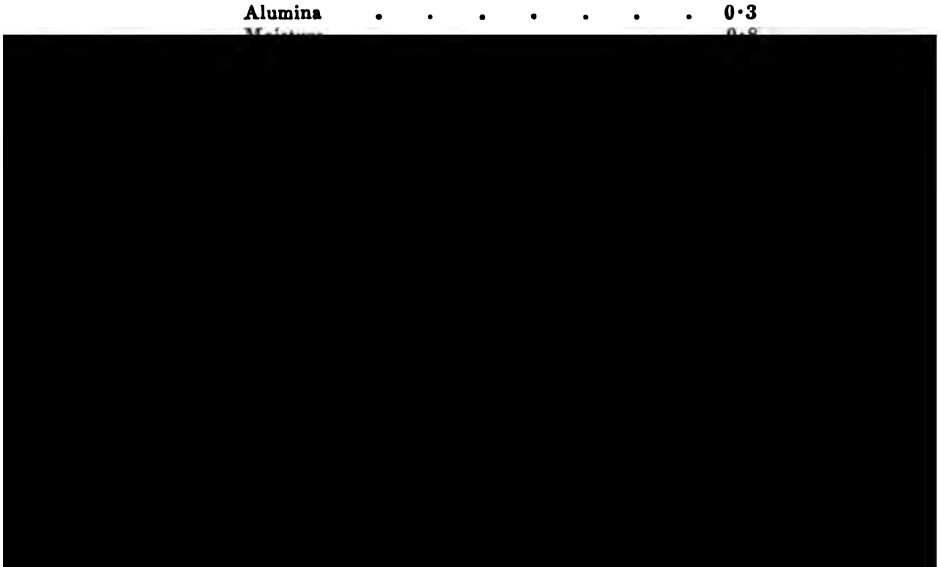
in this district two more conspicuously rocky parts (8 *a* and 8 *b* in the section below), near the top and near the bottom, while between the two, and below the lower one, occur layers of subcalcareous balls, imbedded in shales (dotted in the sketch below).



The whole thickness of the Wenlock limestones, including *a* and *b* and the intervening beds, is about 220 feet. In the great majority of cases throughout the Silurian regions described in this volume, it is the lower part of the Wenlock limestone (8 *a* in the sketch above) which is quarried for lime-burning. This, in fact, is in almost every case the most solid (and, in mass, the purest) part of the rock. It generally requires at least one ton of coal for the calcination of four tons of limestone. In this lower part of the rock corals are locally very plentiful.

The upper beds (8 *c*) are, on the line of the road to Mitchel Dean, remarkably stained with red oxide of iron, in spots and in mass. The texture of the stone is unusually granular, interspersed with cells, and of a dolomitic aspect. This is confirmed by the analysis of Mr. Reeks operated in the Museum of Economic Geology, which gives, in a specimen from the upper part of the Wenlock limestone, on the road from Mitchel Dean to Gloucester:—

Carbonate of lime	60·8
Carbonate of magnesia	28·3
Protocarbonate of manganese	1·4
Protocarbonate of iron	6·7
Silica	1·4
Alumina	0·3
Moisture	0·8



9, (10), 11.—LUDLOW ROCKS.

Around May Hill, the uppermost Silurian rocks are well exposed in several situations. On the western side, the several beds may be well traced downwards to the Wenlock limestones, and on the eastern side we have the uppermost portions in connexion with the Old Red Sandstone.

The whole series stands thus :—

Old Red Sandstone above.

Light coloured laminated sandstones.
Gray laminated sandstones and gray shales, with some short calcareous layers.
Coral beds.
Gray shales, with some calcareous nodules.

Wenlock limestone below.

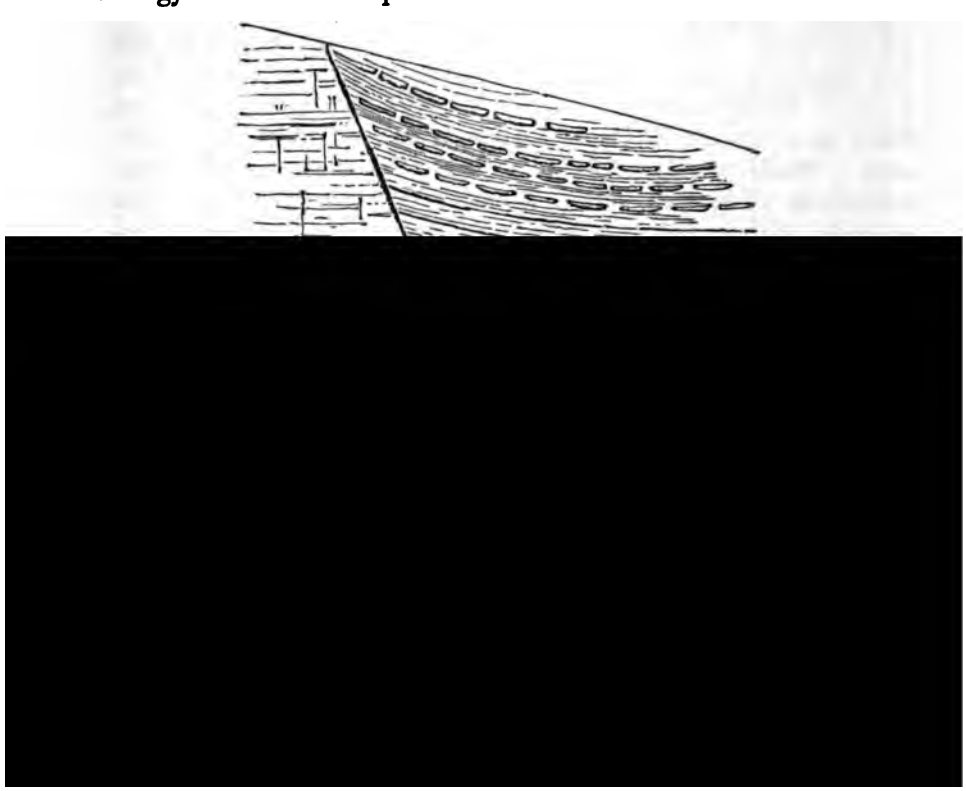
In this group of sandstones and shales there is no distinct band of rock corresponding to the Aymestry limestone. In consequence, the classification, so usual and so useful in Malvern, Woolhope, and Salop generally, of Upper and Lower Ludlow rocks is hardly applicable, until we have inquired, by the help of organic remains, to what part of the Ludlow series these strata belong. Fortunately, these remains are abundant and characteristic, and may be examined in many well exposed sections, especially in an old lane parallel to the Mitchel Dean turnpike-road. Here from the uppermost beds visible near the Old Red Sandstone (the very top beds are supposed to be cut out by a fault) to within a few yards of the Wenlock limestone, 8 *b*, we find fossils most common in Upper Ludlow rocks: viz., *Lept. lata*, *Cypricardiæ*, *Terebr. nucula*, *Avicula retroflexa*, *Serpul. longissimus*, *Orthis orbicularis*, along with *Terebr. Wilsoni*, *Atrypa prisca*, large, *Lept. euglypha*, *Calym. Blumenb.* *Spirif. radiata* and *Sp. ptychodes*, which accompany the Aymestry limestone and lower beds. Upon the whole, these gray beds present principally the characters of Upper Ludlow rocks, both in mineral aspect and organic contents, and these characters go through a greater thickness than usual, and approach so near to the Wenlock limestone as to leave little doubt of the fact that the Lower Ludlow rocks are nearly extinct in the southern and western parts of the May Hill section. It is a remarkable circumstance, bearing on this subject, that these same beds are *thin* on the western side of Woolhope (of which the May Hill district is a continuation), while there the Upper Ludlow beds are rather thick, and very fossiliferous. The Ludlow fish bed has not been found in May Hill.

12.—DOWNTON-BEDS, OR SANDSTONES OF CLIFFORD'S MINE.

In another particular, the Upper Silurian beds of May Hill correspond with those of Woolhope: viz., in the light-coloured white or yellowish laminated sandstones, which lie between the Old Red Sandstone and the Upper Ludlow gray shales. These beds are very extensively seen on the eastern side of May Hill, and quarried for flagging and walling. They correspond to what Sir R. I. Murchison calls the Downton beds, near Ludlow, to the fine flagstone beds of Hall Court, on the western side of the Malvern Hills, and still more precisely to the flaggy beds which are dug on Gorstley Common, in the southernmost part of the Woolhope range. But they have no particular relationship to the beds called "Tilestone" in South Wales.

In these sandstones no fossils have yet been determined, but there are many traces of plants; thus completing the parallel already drawn between these rocks and the similar beds of Malvern, Gorstley, and Woolhope.

Near the Rock Farm, the road-cutting discloses a fault, ranging N.N.W., on one side of which (eastern) is the Upper Ludlow rock; on the other, thrown down and somewhat bent, are laminated red shales and sandstones, with a green band, some black-grained sandstones, and a layer of *Lingulæ* and black carbonaceous spots. Here we have analogy with the Woolhope district.



(cornstone), altogether about 5600 feet thick, in which mica is remarkably prevalent, while in the Silurian strata it is (except in some of the Caradoc and Downton deposits) rather remarkably deficient. The whole series is rich in red peroxide of iron (locally reduced to protoxide in spots and bands), and almost absolutely devoid of all organic remains but fishes, while in the Silurian rocks the iron appears as a blue or gray oxide, and the Silurian strata are full of marine exuviæ of many grades; but amongst these fishes are the rarest of treasures.

16.—LOWER LIMESTONE SHALES.

In a basin of the Old Red Sandstone lies the valuable carboniferous deposit of the Forest of Dean, supported by a mass of mountain limestone, and a thinner band of shales and sandstones, the whole series bearing this aspect:—

Carboniferous System.	19. Coal formation.
	18. Millstone grit.
	17. Mountain limestone.
	16. Shales, thin limestones, and sandstones.
	Old Red Sandstones.

In the carboniferous system generally protoxide of iron occurs, instead of the peroxide of the Old Red; and this is accompanied by a great abundance of organic exuviæ. Red oxide of iron occurs, indeed, in particular repositories, abundantly in the mountain limestone of the Forest of Dean, as elsewhere; but the colouring principle of the shales, sandstones, and limestones, taken generally, is protoxide of iron. The plants, stems, and branches, while generally agreeing with those well known in coal districts, have a particular affinity to some of the fossil plants of North Devon. The invertebral remains and the fishes all appertain to the ordinary mountain limestone genera and species, and the only things to be specially remarked are, first, the *abundance* of the fish remains, which evidences the relation of these beds to the shales, sandstones, and limestones above the Old Red of Caldy Island; and, secondly, the occurrence of the sharp-winged spiriferæ, which nearly match those of North Devon.

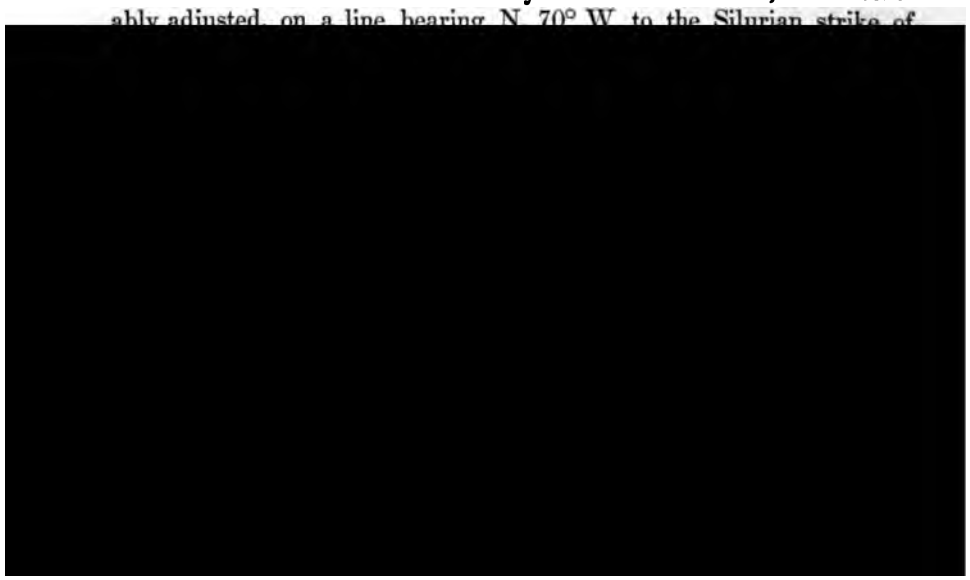
MOVEMENTS OF GROUND IN THE MAY HILL DISTRICT.

On a great scale, the May Hill strata have, to the districts of Woolhope and Malvern, the same relation which the stem of the letter Y has to its branches. In the narrow dome of May Hill, directed N.N.W., we recognize the ramification toward the wider dome of Woolhope; and in the undulations near Huntley, Blackhouse, and

taken by the author of this memoir while engaged in measuring the Palæozoic beds; and, in several subsequent visits, the fish beds were invisible. As far as yet appear these beds are in every place accompanied by marks of drifting. They may have been deposited very near the shore.

The engraved plan and section of the Silurian beds at Tite's Point are offered as incentives to farther research.—(Pl. 4.)

In proceeding from west to east we pass over a broad series of micaceous flaggy, much jointed, purple, sandstones and shales, before arriving at any distinctly fossiliferous beds. These appear with so nearly the same mineral aspect and substance, that by the fossils alone is any boundary to be drawn. Rather it may be said that the lowest part of the Old Red series admits Silurian fossils in thin bands two or four feet apart. There are first *Leptæna lata* with bones in thin layers, partly calcareous and even nodular, alternating with thin sandstones and shales of a purple hue. Five layers were noticed containing bones and scales in a horizontal width of 104 feet, which (the dip being from 26° to 18°) may give a thickness of 40 feet. At depths of 7 feet and 14 feet in this series are shelly bands, at 25 feet a coral band in shale, at 28 feet an orthoceras. At a depth of 65 feet from the first observed bed of *Leptæna lata* and bones, is a remarkable band of *Terebratula navicula* in shale, followed by other bands of the same species, with other fossils and corals in limestone layers, to the depth of above 80 feet from the first bone bed. The beds which follow are properly referrible to Wenlock limestone, forming a double anticlinal. On the eastern side this limestone is covered by *Leptæna depressa* in lumps, then by the beds of *T. navicula* and corals, and finally by a series of laminations with *Lept. lata*, *Orbicula*, and *Cypricardia*, corresponding (in a weathered state) to the (unweathered) fossiliferous beds first noticed on the west. The series is closed by the New Red marls, unconformably adjusted, on a line bearing N. 70° W. to the Silurian strike of



While traversing every part of the Silurian area which extends from Tite's Point to the parallel of Berkeley (above three miles), we discover only very feeble sections, where the roads and ditches cut below the soil. Along the nearly straight boundary line from Tite's Point to Berkeley, we sometimes observe, as at Middleton House, a conformity of westerly dip of the Silurian and Old Red beds. Near Hayne's farm, where the outline veers round to the east, is a quarry of nodular shales, partly fossiliferous, dipping to the south 25°. Again, in the road east of Berkeley, we have a succession of the lower beds of the Old Red Sandstone (red micaceous laminated shales and sandstones), vertical and twisted, or reversed, ranging to the N. and N.E., followed by a considerable breadth of gray, greenish, or reddish thin laminated Silurian shales, ranging N.N.E., and dipping eastward 60° and 70°. No fossils were found in this group.

On the eastern boundary we have, from Tite's Point to Nubbis Ash, a narrow band of New Red marls, only 100 yards in breadth, beneath lias limestone, inclined to the E. (in one place, near Patch's Wood, not less than 30°), and there Mesozoic strata rest against Silurian thin laminated shales, with a few subcalcareous balls. They are seen in vertical position about Pocklington, but are nowhere else distinctly exposed.

The above diagram explains these singular relations,—O, being Old Red vertical, or reversed; S, Silurian vertical, or twisted; N, New Red; and L, Lias, dipping 30° E.

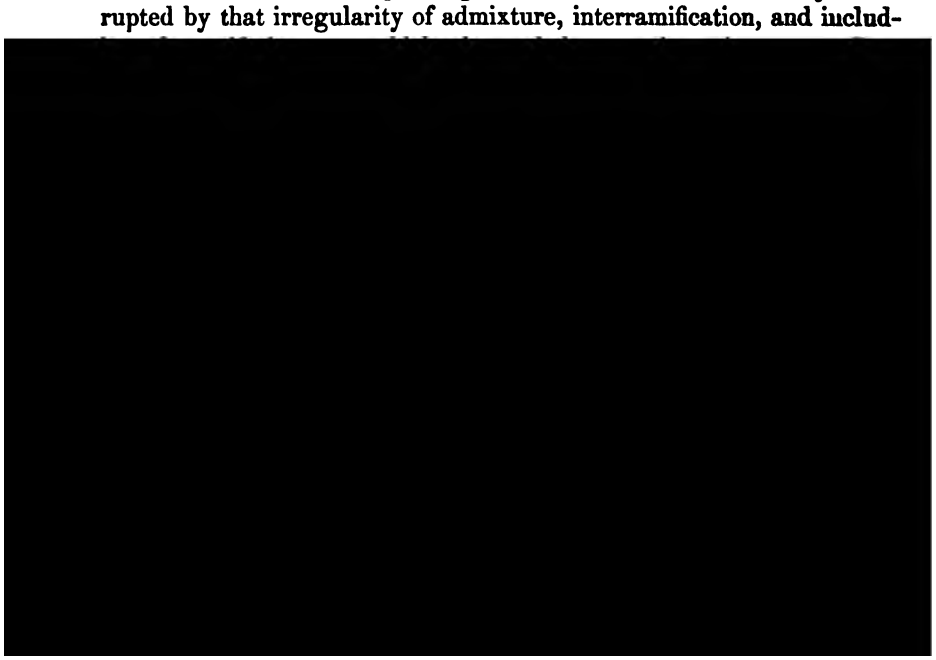
We find, on proceeding south of the road from Berkeley to Nubbis Ash, no important exposure of the Silurian strata about Berkeley Heath, Kit's Green, Cockshute Farm, or Ryeham. On the eastern side the New Red beds are continuous, and widen much, and are often partially exposed. Having crossed the rivulet near Ryeham, we find, about Oakley and Swanley Green, thin laminated Caradoc sandstones; at Woodford Green they are quarried and become very fossiliferous, and we are no longer in doubt as to the prevalence of this rock in the direction of Damory Bridge to Avening Green, and, after a short interruption, by a deposit of New Red in Tortworth Park, to Charfield Green.

The country lying north of the Ryeham stream, contains, as far as we have been able to judge, beds on the junction of the Upper and Lower Silurian strata. The principal part is perhaps occupied by Wenlock shale, (the very lowest part), or the Caradoc sandstone, (the very uppermost part); we have no evidence from fossils to settle the point. South of the Ryeham stream the region is mainly Caradoc sandstone, with

interposed trap bands, which appear in lines ranging E.S.E. at Woodford Farm, and in Michaelswood Chace, at Damery Bridge, and at Avening's Green. Two of these bands re-appear in Charfield Green, ranging N.N.W. The dislocation which accompanies the trap line of Avening Green, through Crockley Wood, is traced on the map. Thin bedded limestone, red and splintery (like the lowest Woolhope limestone in texture), appears frequently in the line of this fault.

The mineral character of the traps, and the alterations of the stratified masses, which occur on the line of these outcrops, have been largely described by Mr. Weaver and Sir R. I. Murchison. The following notices are restricted to what is necessary for the general purposes of this memoir.

The mineral character of the traps varies from ordinary close-grained greenstone, of subprismatic and concretionary (ball) structure, to largely vesicular amygdaloid. In the basis of the rock are scattered crystals of glassy felspar, nodules of various size and shape, consisting of calcareous spar, quartz, agate, calcedony, invested and mixed with green earth, and enclosing amethystine or clear quartz crystals in central cavities. The colours of the mass are extremely variable, especially near the surface, or where water has passed down fissures. In cracks of the stone appear prehnite, sulphate of strontian, sulphate of barytes, brown spar, steatite, and carbonate of lime. The manner in which the trap thus variously constituted appears among the strata, is of that kind denoting irruption and partial interposition. About Charfield Green, and in the line from Avening Green, through the wood, the trap shews for certain distances a parallelism to the stratifications and a lamination of its own substance corresponding thereto, but this is continually interrupted by that irregularity of admixture, interramification, and includ-



seen in the mountain limestone of Mendip, at Uphill, and King's Weston. These are certainly to be regarded as igneous rocks irregularly effused on the sea bed during the period of the formation of the mountain limestone, as the Malvern greenstones were effused in the early Caradoc period. By the same rule the Tortworth Traps are of the Caradoc period, and belong to what is now a large class of igneous products, much studied by Professor Sedgwick in North Wales, and familiar to the members of the Geological Survey in South Wales. They are, in fact *contemporaneously effused Traps*, most probably the fruit of limited and repeated pressures on the interior liquid masses of the earth, followed by solidification at small depths below, or even in part at the surface of the sea bed.

The greenstone dykes of Bartestree and Brockhill (pp. 180, and 157) belong to a quite different class,—a class of melted rocks *injected* by pressure into *vertical fissures* of the preconsolidated strata, at some later epoch, probably in the midst of the carboniferous period.

The metamorphic effects caused by these rocks on the Silurian strata are merely slight induration and change of colour.

Returning to the vicinity of Woodford Green, we perceive that the Trap region which has been thus noticed, forms one branch of a fork, running to the S.E., while another passes to the S.S.W., by Falfield Green and Falfield Mill, to Whitfield and Horseshoe Farm. This westward branch is characterized by two bands of Wenlock limestone highly inclined, fossiliferous, accompanied by shales, and very much reddened by oxide of iron. They dip 45° eastward, that is to say, under the Old Red and limestone of Tortworth, as in the eastern branch of Silurians the beds of Caradoc sandstone with Trap dip westward, under the same overlying strata.

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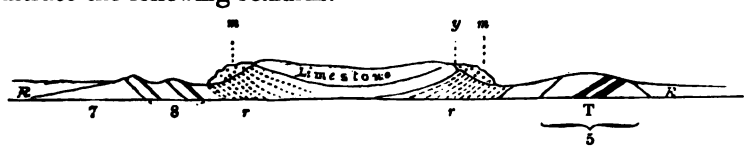

In the first place it may be observed that the Old Red and mountain limestone of Tortworth lie in a shallow synclinal basin, between and upon forked Silurian strata, which dip in the same direction as the carboniferous beds, and more steeply. Secondly, it is plain that either the Silurian basin thus indicated, is not really conformed to the overlying Red Sandstones, or, we must admit a fault, along one of the edges of the Old Red strata:—a down fault on the western edge or an upthrow on the eastern. (There is a fault passing through the limestone of

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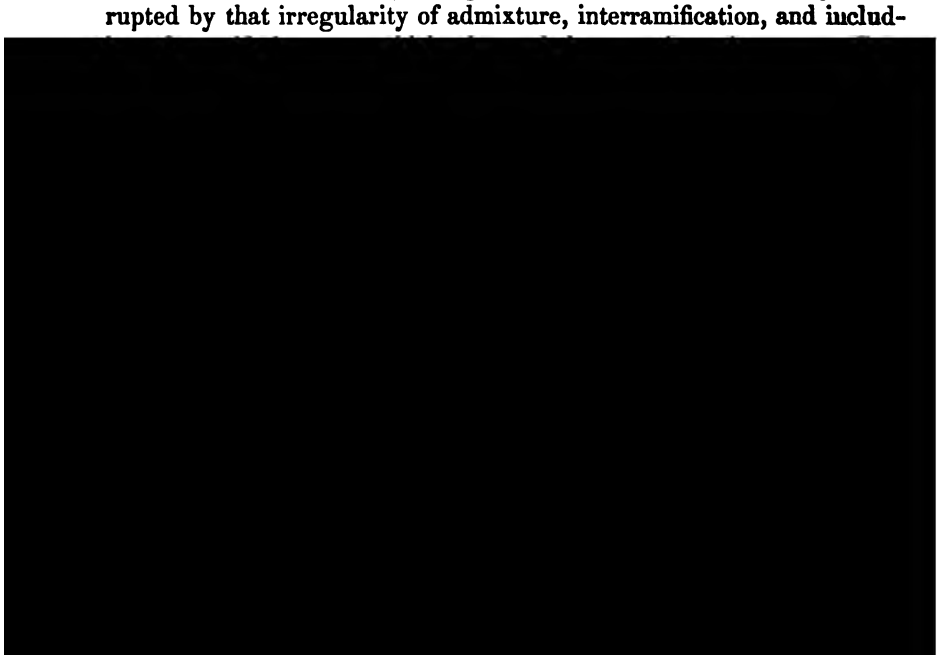

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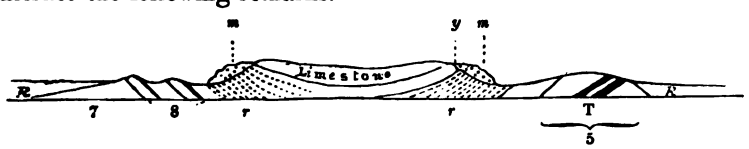

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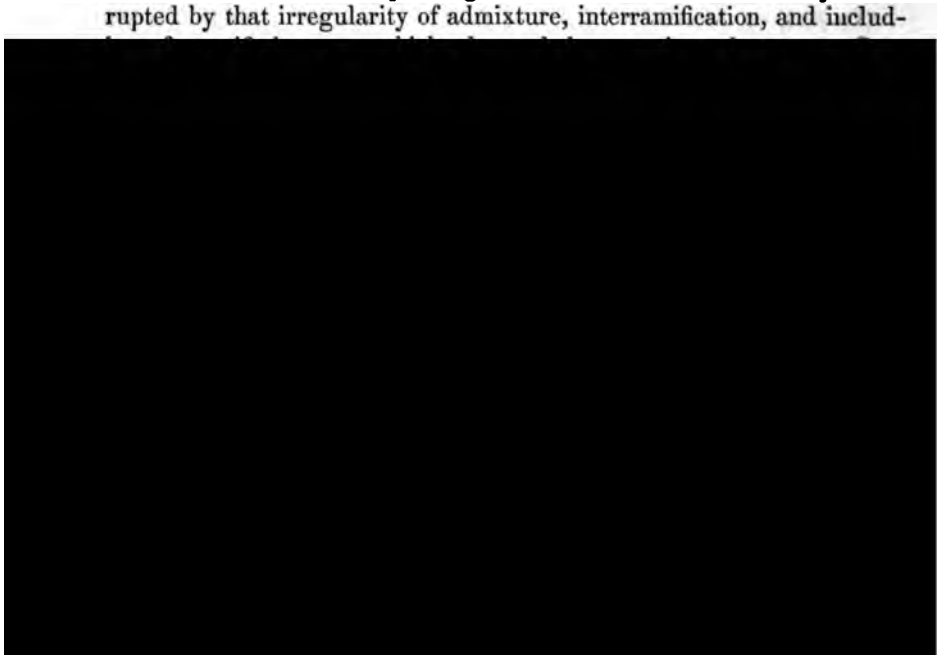

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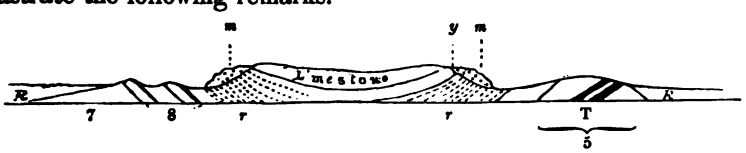

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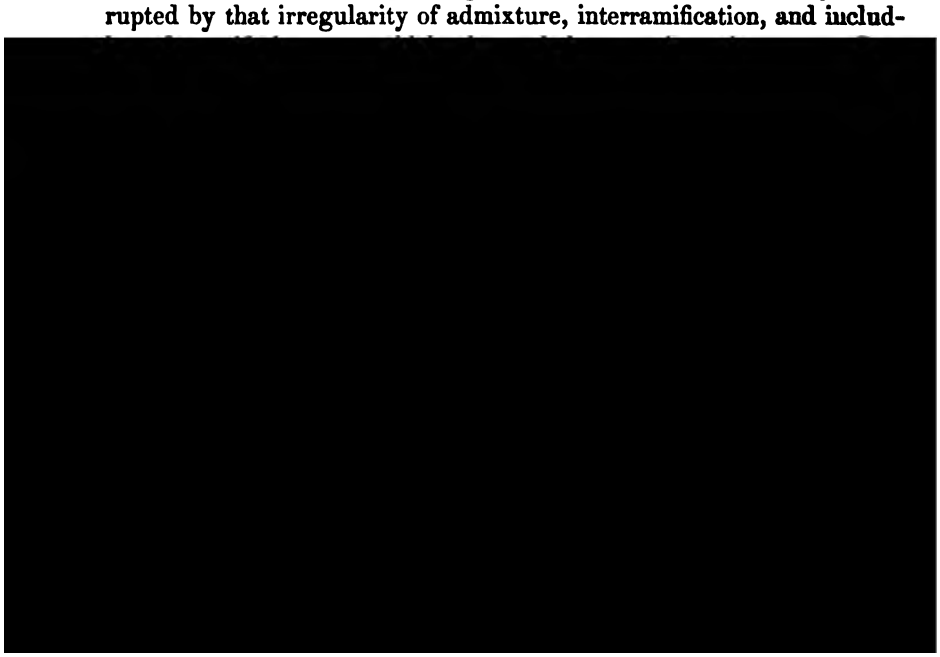

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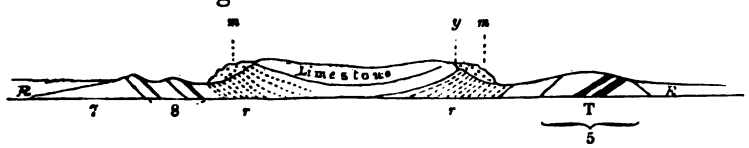

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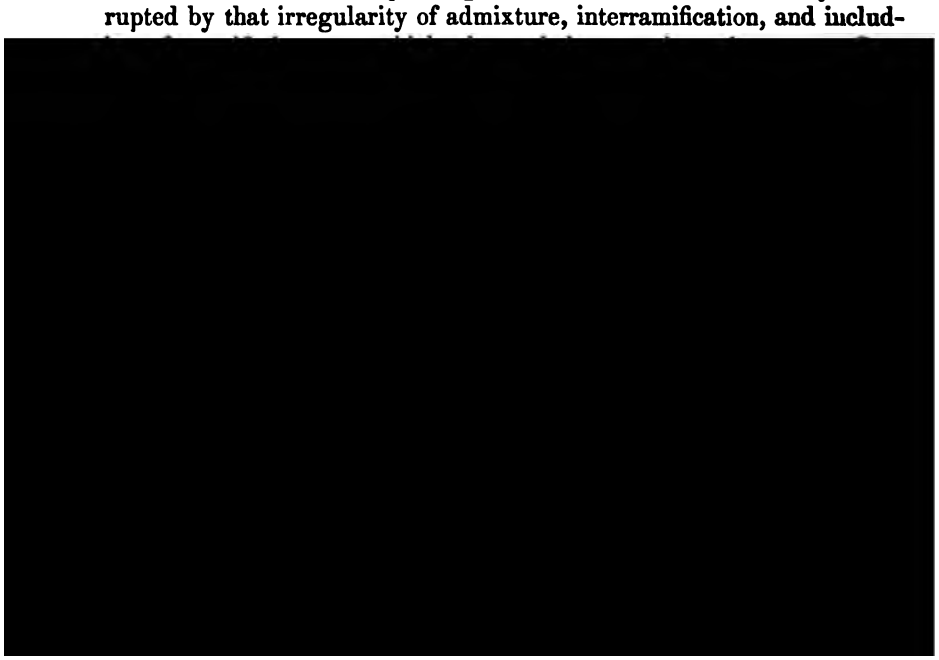

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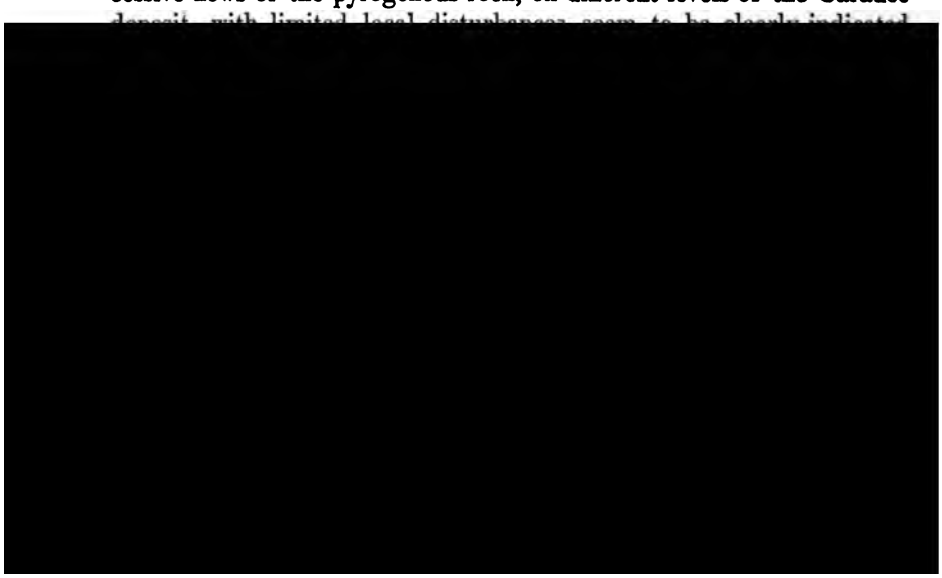

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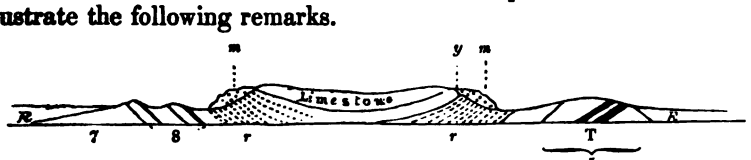

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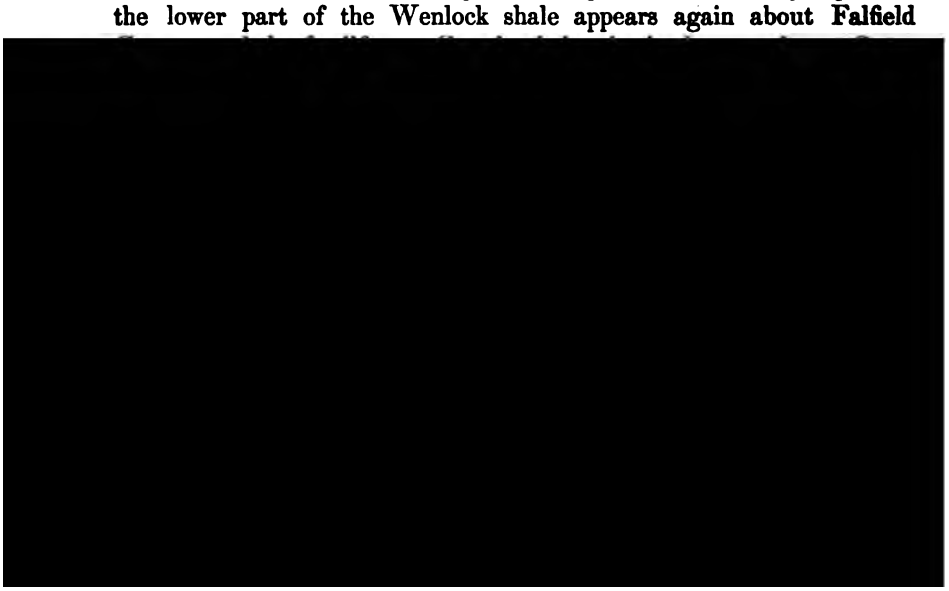
Cromhall and the coal of Cromhall Heath, but this does not affect the present question). Of such a fault there is we believe no evidence. Yet if a line of fracture, throwing up on the E., were drawn from the southern side of Charfield Green towards N.W., so as to pass through Tortworth Copse and below Tortworth Court, toward Crockley Farm, it would contradict no known peculiarity of the distribution of the Caradoc and Wenlock beds, and would pass along a line where there seems reason to conclude the Old Red and Caradoc series may actually be in contact. There is, however, no supposition in the diagram we have constructed, which shews only what is really known, and we shall now notice it in a more detailed manner.

The Caradoc Sandstone beds, No. 5, with their included traps, may be seen on the E. at Charfield Green, occupying a breadth of half-a-mile, with a dip always to the westward, which on the average is not much below 30°. If there be no fallacy in the case, the thickness of this whole series is about 1200 feet. The upper part, that seen nearest the Tortworth Hills, is more shaly than the lower parts. In the lowest part, lying farthest eastward, the fossils abound most, and in some of the beds there observable trap masses are included. Beds of the Old Red Sandstone are the next strata which appear above; there is no actual contact visible, but the vertical interval is under 350 feet, the horizontal interval 700. This may be on the line of the supposed fault. From the phenomena it is concluded that in the 1200 feet we may suppose the upper part to correspond with the shaly and gritty series of the Berkeley district; that is to say, to represent the lower part of the Wenlock as well as the upper part of the Caradoc; there being in this country only one or two thin calcareous layers (seen in Crockley's Wood) to represent the Woolhope limestone.

On the western side the shaly and sandy series which may represent the lower part of the Wenlock shale appears again about Falfield

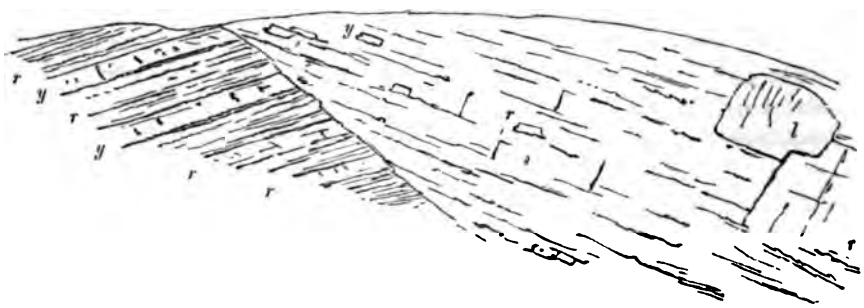


Red beds of Tortworth Park. In one place only can a clear section be examined of the beds immediately below the Old Red, and that is at Horseshoe Farm, towards which the limestone of Whitfield dips in a southward direction. At this place we have the Red Sandstone, and conglomerate in a quarried edge; below it a series of fossiliferous sandstones and sandy shales, with two bands of limestone, the upper very much reddened, and resembling the thin red limestone on the line from Avening Green to Crockley Farm. The fossils here collected have not yielded very uniform or satisfactory results. Sir R. I. Murchison found *Cypricardia amygdalina* in the upper part, and *Asaphus caudatus* in the lower part. The collectors for the survey have added to this list.

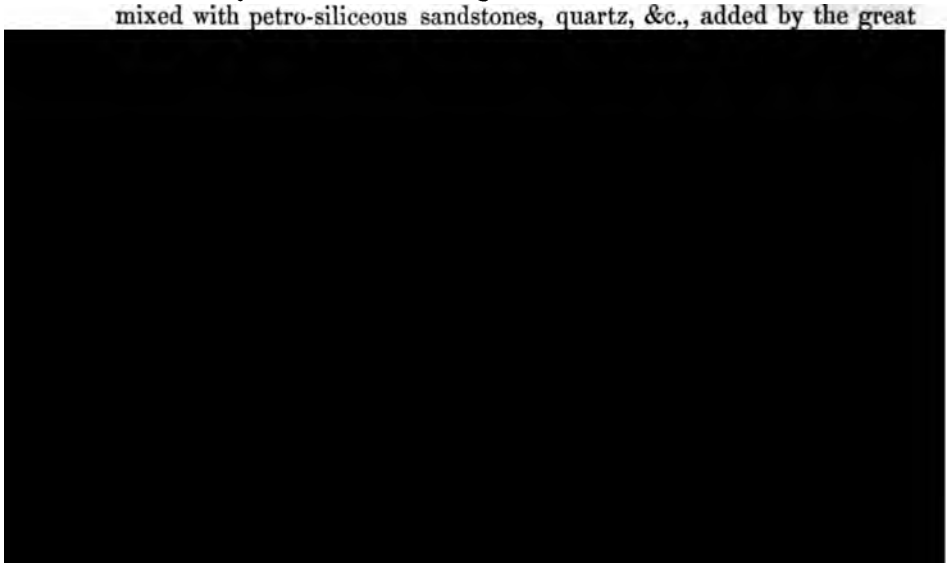
The Old Red beds which lie upon the Silurian strata exhibit, *in their lower part,* conglomerate bands; above these red and gray micaceous sandstones and shales (*r*), then alternations of yellow sandstones and red marls, and finally, as the upper member passing into the limestone series, yellow sandstones (*y*), of considerable thickness (partially stained black), very little micaceous, and clearly corresponding to part of the series of strata near Pembroke in South Wales, which lies at the top of the Old Red, and to a portion of what Mr. Griffith calls the Yellow Sandstone of Ireland. Above is the mountain limestone. (See section, p. 195). This section of the Old Red is remarkable for its small total thickness; for the occurrence of conglomerate in its *lowest* part (the conglomerate of Carmarthenshire is at the top, and all that of the Ross district at least in the upper part); and for the thick capping of Yellow Sandstone. We can admit here only the *upper part of the Old Red series;* the lower part is entirely deficient; the Old Red then is *not conformable* in respect of *area* and horizontal extent with the Silurian strata, though its dips are in agreement with them. The presumed unconformity of the Old Red to the Silurians of Berkeley and Stone is thus *confirmed;* and here, on the southern verge of the English Silurians, we have, repeated, the case already established on the southern border of the same rocks in South Wales, a case of real unconformity of area between the Old Red and the Silurian strata, *without local disturbance of the dips,*—a very important conclusion.

It is not necessary for the purposes of this memoir to describe the peculiarities of the limestone of Tortworth, sometimes oolitic, often reddened, and occasionally dolomitic, or the coal measures of Cromhall and King's Wood. But there is a feature of the district connected with the ancient denudations of the Palæozoic strata which must be noticed. There is round the hilly district of Tortworth a curious old pebbly beach, lying in (or rather at the littoral edge of) the New Red marls, and almost continuously bordering the steep edge of the carboniferous strata and Old Red Sandstone. This pebbly mass is partially

though irregularly bedded; it is full of fragments, chips, and boulders, of the adjacent and overhanging rocks, and its cement, or general base, is red or yellow sand and marl, or a calcareo-magnesian carbonate. It is often full of sparry cells. It is therefore by all its characters equivalent to the "Magnesian Conglomerate" of Bristol, &c., and has been thus described by Sir R. I. Murchison. (*Sil. Syst.*, p. 450.) Very good sections may be studied in several parts of the district, especially in the roads near Tortworth Rectory. One example is given in the accompanying diagram, where on the left is a series of upper yellow



sandstones (*y*), and red sandy shales (*r*), of the Old Red, dipping southwards, or *into* the Tortworth basin; and on the right a group of magnesian conglomerate less regularly bedded, mostly of yellow colour with red bands, having angular fragments, rather than pebbles, of red (*r*) and yellow (*y*) sandstone, and blue carboniferous limestone (*l*). These layers dip northwards, that is to say, outwards, or *from* the Tortworth basin, towards the ancient Erythrean sea, of which they are certainly the littoral boundary. In this case the accumulation of the materials is under the very cliffs which yield them, but elsewhere this is not always observed; the fragments have been drifted, rolled, and mixed with petro-siliceous sandstones, quartz, &c., added by the great



present no clear and certain evidence of their occurrence has been found, except at a few points * along the Ocrynian chain of Devon and Cornwall, where alone they can be expected. If a line be drawn east and west along the anticlinal of Mendip, Glamorgan, and Pembroke, into Ireland, and through Cork and Kerry to Dingle Bay, we find, north of this anticlinal, the Silurian type of Palæozoic strata, everywhere appearing from beneath the Old Red or carboniferous rocks; south of it is developed that complicated system—including mineral and organic analogies with the Silurian, Old Red, and carboniferous limestone—to which the name Devonian has been applied. Viewed in a general manner, the relative geographical distribution of these great masses on the continent of Europe is similar; the Silurian type is Scandinavian, the Devonian type is Allemannic; but in North America (which seems to be the great centre of Palæozoic life and stratification) both these great groups are developed together in full proportions, followed by the representatives of the carboniferous and magnesiferous systems of Europe. (Consult the works of Murchison, Rogers, and Lyell).

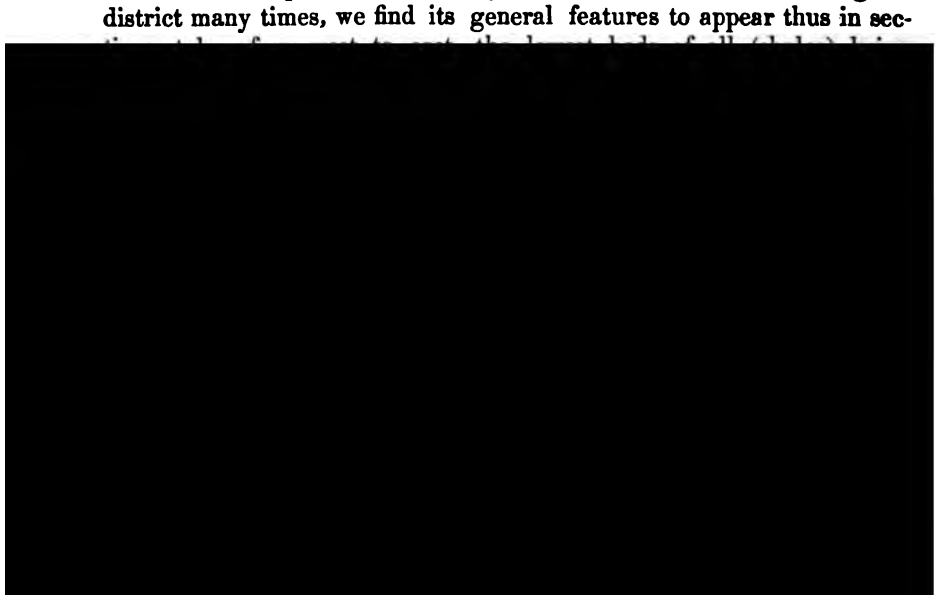
Another line drawn north-eastward from the Mendip Hills, leaves on the N.W. all the visible Silurian stratification of England; and continued to the continent, leaves on the N.W. the Silurians of Gothland and the Neva. In the angle included by these two lines, and about 20 miles from each of them—so far therefore at least from either Silurian shore—is the region of Usk, an elliptical area of Ludlow, Wenlock, (we can scarcely add Caradoc) strata, eight miles long and four miles broad, elevated on an anticlinal axis, between the carboniferous basins of South Wales and the Forest of Dean.

If a line be drawn from Clytha to Llandegfydd, it will pass nearly along the major axis of the elongated Silurian district of Usk, in a direction from North 12° E. to South 12° W. South-west of Llandegfydd, from one to two miles, is the detached Silurian district of Llanfrechfa, in two small patches. The points defining the larger area are Clytha, Usk, Llangibby Castle, Llandegfydd, Slovad's Farm near Panteg, Little Mill, Melyn-y-coed. Within this area is one almost continuous band of limestone, observable at Trostra, Radyr, Cefn Ila, Prescoed Farm, Cilwrgyr, Tynewydd, &c. The elongated area included between these points, runs in a direction from North 5° E. to South 5° W.; its length being five miles, and its greatest breadth two-and-a-quarter. The conformity of these two areas leaves no doubt of the generally symmetrical character of the elevation of the Usk district, which is confirmed by the universally outward dip of all the beds toward and beneath the Old

* Mr. Peach's observations on the south coast of Cornwall are here referred to. They have been considered by Sir R. I. Murchison to warrant the conclusion in the text.

Red Sandstone, which everywhere encircles the district. Yet, on looking into the interior, or following the outer edge, we perceive many signs of irregular folding and fracturing, not always referrible to lines which are symmetrical to the axis of principal upward movement. A short narrow anticlinal axis of the limestone is found ranging parallel to the great axis at Dowlas Farm, near Llanbaddock; and the line of this movement is continued to the S.S.W., by Llangibby Castle and Pen-y-Parc House. Near Radyr Farm the limestone edge turns from a north and south line to one due east and west, and the south dip (10°, 15°) which it here shows, would carry it beneath the edge of the same limestone at Cefn Ila, where the dip is also to the south. Between these points some dislocation is to be assigned, its effect being a re-elevation of the beds which sink from the old quarried edge of Radyr toward the ridge of Cefn Ila. The line of this dislocation is not, however, certainly traceable. The dips of the district are most steady on the western side, most varied on the S.E. They are generally moderate, 10°, 15°, 20°, 30°; but on the south-eastern side, near Llangibby Castle and Dowlas Farm, and on the western side near the High Beeches, they rise to 50° and 60° eastward; and at a place south of Radyr, the dip is to the N.W. 57°.

If we now enter the area for the purpose of ascertaining the order of its stratification, we remark, in the first place, the comparatively small vertical thickness of the whole series of rocks in the district. According to Sir H. T. De la Beche (*Memoirs of the Geological Survey*, vol. i. p. 22), this total observable thickness is 1570 feet. If from this we deduct 590, for the supposed equivalents of Llandeilo and Caradoc beds, the remainder to represent the whole Upper Silurian series, is actually less than the thickness of the Ludlow formation alone, where it is most developed about Ledbury and Ludlow. After traversing the district many times, we find its general features to appear thus in sec-



zone, consisting of thin fossiliferous sandstone, resting on soft shales also fossiliferous.

The interpretation of this section is perfectly clear in the upper part, but somewhat dubious in the lower part. The upper hard rocks which constitute the hilly border of the district, are of the Upper Ludlow and Aymestry formations: the soft shales below correspond to the Lower Ludlow. The limestone beds below are divided by Sir H. T. De la Beche into two portions, viz., the Wenlock and the Woolhope rocks; and with Sir R. I. Murchison, he groups the sandstones and shales below in the Lower Silurian (Caradoc and Llandeilo) series. There is, however, some doubt on these points. The first view of the district undoubtedly suggests that the lowest of the limestone bands, worked at Tynewydd, Glascoed, Cefn Ila, Radyr, and Trostra, is Wenlock rock. The very numerous fossils agree with this view entirely: but the argument from this head is not unobjectionable, for it has been found both in Malvern and at Woolhope, that the organic remains of the Woolhope limestone are, in fact, hardly distinguishable from those of the Wenlock series, except by inferiority of number, a circumstance which may be of merely local occurrence. Turning, then, to the sandstones and shales below, we find the former to resemble closely the upper fossiliferous Caradoc beds, but what are the subjacent shales? There is nothing really analogous with these in all the districts we have examined, nor in the vicinity of Ludlow, below the Caradoc sandstones, and we are compelled to inquire whether they are not really Wenlock shales, the sandstones above being a local deposit, peculiar to this region? If we do not adopt this view, the subjacent shales must be classed as a local and peculiar deposit, a conclusion at variance with the history of the argillaceous deposits of the Silurian series of the English Border. The shales and sandstones which are now in question, appear *beneath the limestone*, at Trostra, Radyr, Glascoed, and Tynewydd, always under similar circumstances. At Trostra, the effect of a curious fault being allowed for, we have on the left bank of the Usk a clear section, as follows:—

Limestone in broad beds, dipping S.E. (12°), with the usual Wenlock fossils.
Shales, with calcareous nodules.
Shale (thin).
Sandstone, laminated, fossiliferous (*Orthis, Terebratula,* &c.)
Shale (thick), with fossils (*Orthoceras virgatum, Leptæna depressa,* &c.)

At Radyr Mill, and in the hill above, these sandstones and shales, slightly fossiliferous (*Terebratula, abdominal ring of a large Trilobite*) are overlaid by the limestone containing Wenlock fossils. From beneath the long range of limestone quarries of Glascoed, the sandstone appears frequently in thin beds, and is always more or less fossiliferous, (*Ten-*

taculites annulatus, Orthis, Crinoidal joints, &c.); in fact, very like the ordinary upper Caradoc sandstone, *but with a far smaller series of fossils.* Again, at Tynewydd, the series of beds is like that at Trostra, viz. :—

Thick series of calcareous balls } with Wenlock fossils.
Limestone in solid beds }

Laminated hard sandstone, at Radyr.

Shales soft, yellowish, with fossils, the part toward the Tucking Mill being the lowest beds observable in the district, and containing two thin calcareous bands.

There remain two general observations on the organic remains of these sandstones and shales. The fossils and the sandstones are not only few in number as compared with the ordinary Upper Caradoc bed, they are also not such as are commonly and immediately recognised as characteristic of such. At Bryn Craig, where the greatest number has been found, we have,—

Calymeme Blumenbachii, Nerita haliotidea, Murchisonia in coral, *Pullastra complanata, Mya rotundata, Cypricardia solenoides, Cucullæa antiqua, Nucula, Avicula lineata, Atrypa tenuistriata, Avicula retrofleza, Spirifera octoplicata* (Sil. Syst.), *Terebratula bidentata, Terebratula crispata, Terebratula Stricklandi.*

Now this does not appear to be really a series of Caradoc life.

Again, the subjacent shales of Tucking Mill, with their thin limestones near the bottom, are more like Wenlock shales than any others we can compare them with, and if (as the country seems to indicate) the more richly fossiliferous shales of Craig y Garcyd (on the right bank of the Usk) belong to the same group, this analogy is strongly confirmed. The fossils of Graig y Garcyd are surely not older than the Wenlock shale, for they include

Calymene variolaris, C. Downingiæ, Asaphus caudatus, Asaphus longi-

points for research, in the very easy gradation by which changes into the Old Red series. We shall examine this gradation at some points on the eastern edge of the district, commencing in the north, on the line of the road from Ragland to Abergavenny at Clytha. Here the Upper Ludlow beds, exposed in the road cutting, yield *Cypricardia amygdalina, Leptæna lata, Spirifera ptychodes, Terebratula nucula*, &c. Following the boundary to the south, by Trostra Hill to the Camp Hill, near Pentwynn, junctions frequently appear. At Trostra Hill Farm, the junction beds, with a mineral character corresponding in part to the micaceous part of the lowest Old Red, contain *Asaphus caudatus, Orthoceras virgatum, O. pyriforme, Leptæna lata, Atrypa prisca, Cornulites serpularius.* Lancayo Hill and the roads near Usk offer, however, the most instructive sections. At Hill Barn, and in the steep descent from it to Lancayo Farm, we have (dipping E. 20°).

R. Micaceous laminated sandstones.
Micaceous sandstones, with spiral shells (*Turritellæ.*)
Micaceous laminated sandstones.

L. "Mudstones," hard and soft, with shells.
Bands of nodular limestone.
Layer abounding in shells.
Mudstones, hard and soft, with nodular bands.

The upper series (R) is mineralogically allied to the Old Red. Its spiral shells are frequent in the lower beds of that deposit, and they also occur mixed with abundance of ordinary Ludlow fossils in other parts of the district. These beds are usually brown rather than red.

Of the lower beds (L) about 150 feet may be seen, the remarkably shelly layer being 50 feet deep in the series. The fossils most frequent are *Leptæna lata, Orthis orbicularis, Leptæna depressa, Atrypa prisca, Spirifera ptychodes.*

In Lancayo Hill, further to the S.W., we have below the Old Red and the beds above grouped together, we have (dipping E. 14°) a calcareous band, corresponding to the Aymestry rock of Malvern, and yielding *Asaphus caudatus, Leptæna depressa, Spirifera crispa.* In the lower parts coral is accumulated in thick nodular beds, and accompanied by *Mya rotunda, Atrypa prisca*, &c.

In Cock Wood, north of Usk, we find the following series:—

Old Red Sandstone.
Micaceous sandstone in thin beds, of a greenish hue, with *Leptæna lata* (large!), and other fossils.
Thicker bed, of brownish gray sandstone, full of fossils, as a *slender crinoid, Lept. lata, Orthis orbicularis, Tentaculites tenuis, Homalonotus, Cornulites.*
Micaceous sandstone in thin beds (as above).
Thicker bed (as above), less fossiliferous.
Alternations of the same beds follow to a depth of 40 feet, without reaching the *richly fossiliferous layer* of Hill Barn.

About Usk Castle, two or three excavations yield abundance of fossils. In the lane leading from the Rugland road (east of the Castle), we

ascend Old Red and pass to Silurians. At the head of this lane, a band of limestone is formed of *Terebratula navicula*. Farther on, in a small cliff against the road, is a band of trilobites, and below it rows of nodular limestone (dip. S.E. 8°.) Here occur *Nucula ovata, Leptæna depressa*. Beyond is a spot amazingly productive, in a bed corresponding to the rich bed of Hill Barn, which here may be 40 feet deep in the Upper Ludlow series, but an exact measure is impracticable. This bed is entirely covered and filled by *Cypricardiæ, Orthides, Lept. lata, Orbiculæ, Terebratulæ* (*Terebratula canalis* and *Terebratula navicula* occur here) *Aviculæ, Orthoceras ibex*, &c. (Specimens also occur of *Terebratula Wilsoni, Lingula Lewisii*, and *Atrypa prisca* (large).

Lower than these beds are dry wallstones, (corresponding to the building stone of Ludlow and Stoke Edith), and they yield several of the same species.

On the right bank of the river at Llanbaddock, a fine section is laid open for examination on the line of the road, (dip E.S.E.). Here broad shelly floors of Upper Ludlow rest on bands full of subcalcareous nodules, and these on hard blue wallstone a little undulated. The upper part contains the very shelly series of Usk, the middle part yields Cyathophylla and Favosites, and the lower part, *Pleurotomaria Lloydii, Atrypa galeata, Spirifera radiata, Cardium striatum, Lept. depressa*.

If we now pass to the detached districts of Llanfrechfa, the fossiliferous series there exposed offers, with mineral analogies to the Old Red, and abundance of the *Turritellæ*, (which have already been shown to be the highest known fossils in this region), many shells of the Upper Ludlow series. The following were observed on the spot (1841) :—

Orthoceras imbricatum, O. bullatum, Cyrtoceras læve, Bellerophon globatus, Euomphalus carinatus, Turbo carinatus, Turritella ornata n. s., *T. obsoleta, Pleurotomaria Lloydii, Cypricardia cymbæformis, Avicula rectangularis, Terebratula navicula, Orthis lunaris, Leptæna lata*, (some

the narrow elevated Silurian bands of Pembrokeshire at Freshwater East.

Again, we observe in the Usk region, a more frequent alternation of the fossiliferous and non-fossiliferous beds which constitute the transition from the Silurian to the Old Red types of strata. Using a new term, we may say this transition series is more *analyzed*, (more resolved into its parallel elements), near Usk than in the Malvern area; a circumstance *also observable on all the western line of* Upper Silurian boundary. Thirdly, we observe that the fossils of these transition bands and of the Upper Ludlow group, are more distinctly collected *in separate beds*, in the vicinity of Usk, than in the neighbourhood of Ledbury. There, for example, we have,—

A band characterized by *Turritellæ;*
A band rich in *Terebratula navicula;*
A band crowded with *Cypricardiæ.*

Hardly one of these bands or anything equal in importance to them occurs near Ledbury. (The small *Lingula* in the Downton beds hardly forms a band.) At Halesend quarry, in the North Malvern country, however, we find illustrations of this circumstance, by a band of *Orthoceras*, layers of *Leptæna lata*,* and a layer with *Terebratula Wilsoni*. This character of *banded distribution* of fossils is indeed never absent from any of the Lower Palæozoic regions of the British Isles: it is recognised in Ireland, in Tyrone, and the Dingle Promontory; in Westmoreland; along all the borders of England and Wales, and through the whole interior of the principality. But it is unequal in degree. Confining our attention to the upper limit of the Ludlow rocks, we observe it distinctly in the bone bed and bands of *Terebratula Wilsoni* of Woolhope; in the Downton beds, bone bed and *Terebratula* beds of Ludlow; in the bone beds, and layers of *Terebratula navicula* at Pyrton Passage. But it is perhaps still more remarkable, seems more clearly the *system of distribution*, and extends through greater depths of the stratification along the western outcrop of the Silurian strata, about Horeb Chapel, the Trichrug Hill, Golden Grove, and Myddelton Hall, and in the denuded beds of Freshwater East, in Pembrokeshire. In these places we have,—

Bands of Turritellæ and Trochi;
Layers of Cypricardiæ and Homalonoti;
Layers of Meristomyæ, &c.

Upon the whole, viewed in this respect, the Usk district exhibits in the distribution of the remains of its latest Silurian life, a greater analogy with the *Episilurian* districts of South Wales, than we have found

* Layers of this shell occur in every locality, owing to its great numerical predominance.

in any other of the districts noticed in this memoir—a circumstance of much importance in general reasoning as to the local centres from which the Silurian species were diffused.

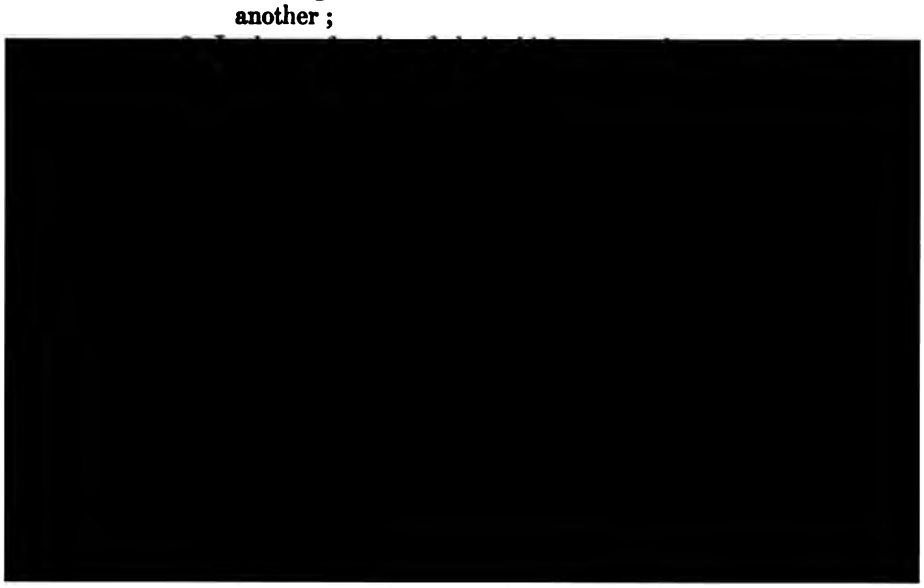
On this point, the *local centres of the Silurian species*, the Usk district suggests some interesting facts as a basis of further inquiry. Here we have *Turritellæ* by thousands; here and at Pyrton Passage, we find *Terebratula navicula very abundantly*, in the latter locality more deep in the series than usual; in the district of Woolhope *Terebratula Wilsoni* forms *entire strata;* while *Leptæna lata* abounds in all these and in other districts. Now *Turritellæ* and *Cypricardiæ* appear to be western and southern forms; the fishes, *Leptæna lata*, *Terebratula Wilsoni*, and *Lingula minima*, northern and eastern forms; *Terebratula navicula*, southern and eastern; *Meristomya*, western.*

In older strata we may, perhaps, refer *Pentamerus Knightii* to a local centre near Aymestry; *Lingula crumena*, to the Caradoc of Malvern; *Atrypa hemispherica*, to the Caradoc of Abberley; *Asaphus Buchii*, to Llandeilo and Builth. These are merely offered as illustrations, or first impressions, of a subject which is soon to engage our closer attention.

GENERAL REMARKS.

Collecting into one point of view the preceding observations in which the Malvern Rocks, minutely described, are compared with the coeval deposits of Abberley, Woolhope, May Hill, Tortworth, and Usk, we see proof,

1. In the conformity of the mineral constituents of the strata of all these districts;
2. In the agreement of the order in which these succeed one another;



of decided general change of deposits—as about or above the termination of the arenaceous Caradoc strata, and their replacement by argillaceous formations, and about or above the termination of the protoxidated Ludlow shales, and their replacement by peroxidated Old Red Sandstones.

Moreover, there is the proof,—

1. In the series of beds which are displaced;
2. In the general mode and system of their displacement;
3. In the mutual adjustment and geometrical relations of the uplifted and depressed strata;

That all these districts, after being part of a sea bed subject to continual or interrupted subsidence, were displaced by one great system of mechanical forces, operating through one period of time.

And finally, there is proof,—

1. In the eroded outline and other characters of the eastern edge of the district, from the vicinity of Bewdley, to the district of Tortworth;
2. In the distribution of conglomerates along this edge;

That after the main effect of the displacements alluded to, the disturbed and elevated district was washed and wasted on the eastern side by the sea of the New Red Sandstone period; under which sea the Abberley Hills were at one time submerged; above it the Malvern summits (at a later epoch?) rose 850 feet, and the May Hill perhaps about 400 feet; while the districts of Tortworth and Bristol were only dry in small and complicated areas. This sea perhaps, (we think probably), received from land in the west, which may have never been again submerged, the tribute of valleys along which rivers may have never ceased to flow since the Palæozoic æra.

We may be permitted to close these studiously condensed descriptions of the detached south-eastern districts of Silurian strata, by an express acknowledgment of the great assistance which we have derived, in the whole course of our survey, from the previous labours of Sir R. I. Murchison. It was our obvious duty to record *facts* which we have seen, and *inferences* which these facts justify; and we experience a high gratification in finding the facts and inferences, regarding many districts and varied phenomena, which we present as the result of our own inquiries, remarkably in harmony with the earlier statements and original opinions of the author of the SILURIAN SYSTEM.

ON THE REMAINS OF LIFE IN THE LOWER PALÆOZOIC STRATA OF MALVERN, COMPARED WITH THOSE IN THE OTHER DISTRICTS.

The remains of the numerous races of animals and plants which occupied the land and sea, in periods before the creation of man, have been sufficiently studied to allow of our believing that the laws which now regulate the appearance, distribution, and succession of organic beings, have prevailed through all the periods since the origin of life in the globe. The ancient world of life differs from that we now see in activity, because life is by providential arrangements distinctly calculated for, proportioned to, and made dependent on, external physical conditions; and as these have varied with time over the whole surface of our planet, so the corresponding forms of life have been made to change. But the *laws* of this *admirable* adjustment of the forms, structures, and habits of animals and plants, to the character and combination of contemporaneous physical conditions remain the same, applicable alike to primeval and to passing events—always influential, and always to be appealed to, because they are part of the plans of the Divine Architect of nature.

The philosophy of organic remains* differs from the philosophy of modern zoology and botany† only by including an additional field of research, the consideration of the succession of organic life on the globe, the history of the successive races and combinations of races of animals and plants, from the earliest eras accessible by man to the present hour. These successions of life mark successive adjustments of the organic to the inorganic constitution of nature, and can only be interpreted by the application of the laws now recognised as governing the living wonders of creation; on the other hand the full influence of these laws, under various physical conditions, and through a lapse of time, can only become known by geological investigation. Palæontology and biology thus become inseparably united as parts of one great science, having for

and Belemnites been successfully compared with Nautili and Sepiæ,* and proved to have had corresponding powers of swimming in the ocean; thus have freshwater and marine shells been precisely distinguished in the stratified crust of the earth; and limestone rocks ascertained to be composed of ancient Zoophyta, comparable to those which now construct the modern coral reefs.

2. To increase the knowledge thus gathered concerning the habits of life of ancient plants and animals, we may next examine the circumstances by which they are accompanied in the situations where they occur in the earth. As some of the shells of the modern sea are now found enveloped in coral, imbedded in mud, or mixed with sand and pebbles, so we find corallophagous bivalves, clay-beds full of oysters, and sandstones and conglomerates rich in various Mollusca. By much attention to these circumstances, we come to know some of the *peculiar conditions* to which each species or each group of species was formerly adapted. The most exact knowledge we are thus enabled to gather concerning various tribes relates to the character of the bed of the sea, its arenaceous, argillaceous, or calcareous quality; but in addition we obtain often probable, and sometimes certain, information regarding the *depth of the sea*, and considerable indications of the quality and *composition of the water*.

3. One of the most certain facts regarding recent plants and animals, is the *limited* natural distribution of each species. That particular islands, certain ranges of mountains and valleys, particular lakes and arms of the sea, should have each their peculiar fauna and flora, may excite little surprise; that plants rooted for life, and animals incapable of locomotion, should be thus circumscribed in area is what might have been expected. But in free air every bird has its allotted and limited range of surface; in the open sea, whales, fishes, and other animals with full powers of locomotion, are equally confined to particular regions, by peculiarity of food, dependence on climate, or other local conditions. The geographical distribution of fossil plants and animals is also limited, and each species has its own peculiar laws, which can only be known by observation. The areas which bound the diffusion of living races are sometimes single, but often there are several detached areas, within which each species may be supposed to have extended itself from a particular centre of origin or colonization, or in which it has been left detached, in consequence of physical revolutions;† so in the fossil world, amidst many irregularities and singularities, we find some, and may hope to find many cases in which the local

* Volta, Buckland, Owen.

† Professor Forbes's Essay in the first volume of these Memoirs may be consulted on this subject.

origin and limited area of distribution of particular races may be sufficiently demonstrated by actual survey of their imbedded organic remains.

4. Could we penetrate the bed of the sea, and examine the several layers of sediments which have successively fallen from its waters, and mark the forms of life which they respectively contain, we should see in these deposits of successive times differences of the organic combinations. Some species found in the lower beds would be absent from the upper; new forms would appear to have been introduced in the series; and thus each species would appear *limited in duration*, because it is certainly limited by physical conditions, and these do not remain the same at successive times, but partake of the general mutation to which all the phenomena of nature are liable.

But geology, which exposes to our view thousands of successive sea beds, produced in a long lapse of ages, declares this great truth of the successive variations of organic life, in clear and strong language. Everywhere the systems of ancient life differ in the different systems of strata, which were deposited at successive times: the greater the interval between these times, the greater is this difference in the systems of life. The more ancient the strata, the more unlike are their organic forms, taken as a whole, to the existing creation; and this difference is recognised not in species only, but in genera, families, and even whole classes of organic beings. Life is a limited gift. Individuals have their appointed length of days; species, genera, families, and even larger groups, are shown by geology to have limited periods of duration, and definite places in the series of natural events. Reptiles, as a class, have no place in the most ancient strata, but commenced their career at a later period; while Trilobites and Orthoceratites abound in these same rocks, and passed away from the theatre of life, when the reptile kingdom began. That every species of

3. The *geological time* of duration of this life; or, in other words, the series of successive depositions in which it is found.

4. The dependence of this life on peculiar mineral or other physical conditions.

The leading result of observations on these points in the palæozoic districts which have been surveyed in 1841, 1842, and 1843, will appear in the following pages, but some preliminary notices are requisite.

ON THE SYSTEM OF LOWER PALÆOZOIC LIFE.

The animal kingdom admits of being classed in four grand divisions, of which one, including the Vertebrata, is decidedly superior; another, including the Zoophyta, is inferior; and the remaining divisions Articulata and Mollusca, may be regarded as intermediate groups, uniting the superior and inferior organizations, and may for the present purpose be arranged as in the subjoined diagram.

Of all these grand divisions examples occur in the Silurian strata, but in unequal proportions. Of 100 species of animals in the Silurian strata, we estimate that

6 belong to Vertebrata.
12 „ Articulata.
60 „ Mollusca.
22 „ Radiata.

In existing nature the corresponding numbers might perhaps be found

10 Vertebrata.
84 Articulata.
5 Mollusca.
1 Radiata.

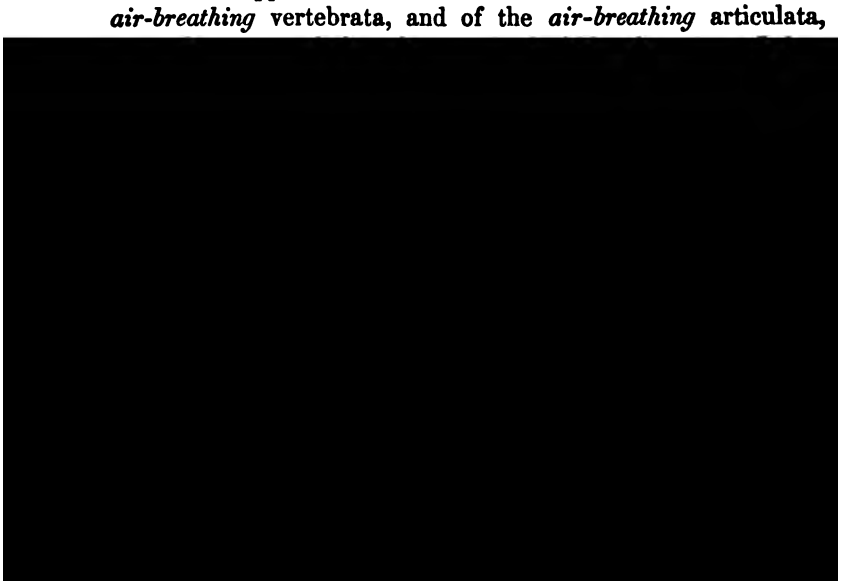
the enormous preponderance of Articulata in the modern fauna arising from the number of land insects; and the abundance of Mollusca in the strata being the consequence of their formation in the sea.

By resolving these four great groups into their constituent classes,

and arranging them in a linear order, we may further analyze th
tion of fossil to recent animal organization, as under :—

Recent Classes.		Silurian Fossil Classes
Mammalia	Vertebrata	———
Aves		———
Reptilia		———
Pisces		Pisces
Insecta	Articulata	———
Myriapoda		———
Arachnida		———
Crustacea		Crustacea
Annelida		Annelida
Cirripeda		———
Entozoa		———
Cephalopoda	Mollusca	Cephalopoda
Heteropoda		Heteropoda
Pteropoda		Pteropoda
Gasteropoda		Gasteropoda
Lamellibranchiata		Lamellibranchiata
Brachiopoda		Brachiopoda
Tunicata		
Echinodermata	Radiata	Echinodermata
Acalephida		———
Polypiaria		Polypiaria
Infusoria		———
Foraminifera		Foraminifera

Thus it appears, that in the marine Silurian strata, remains *air-breathing* vertebrata, and of the *air-breathing* articulata,



ON THE GEOGRAPHICAL DISTRIBUTION OF THE LOWER PALÆOZOIC LIFE.

By the general consent of naturalists, the actual distribution of the species of plants and animals which now live on the surface of the land and in the waters, has been effected by the agency of a great variety of causes, tending to diffuse the germs of organization from the points where it was first created. A given species of plant or animal, is not found indigenous, in two or more separate districts, because it was independently created, or sporadically generated in both, but because its forms have been transported by air, water, or other natural agencies, from the one area in which it was originally created, whether that area be still discoverable, or be lost in the mutations of nature and long successions of time.

It is equally undoubted, that this general law of increase and multiplication, for every species is restrained and rendered definite in its operation by other special laws, so that every species is limited by its organization, and the functions for which that is calculated, within a certain range of physical conditions. If these conditions change in a certain place, beyond the range of possible adaptation permitted to the organization of a species, that species ceases to exist in that place.

Thus ordinary causes, such as a change of elevation of ground, the overthrow of a forest, the draining of a marsh might destroy certain plants; the loss of these might be followed by the extinction of insects, which lived on them, and the absence of birds which fed on the insects or the fruits, no longer attainable in that place. Similarly in the ocean, the deviations of great currents offer at once a cause for distribution to new, and for extinction in old localities, of species which depended on the temperature of the current, on the food which it might bring, or on other physical conditions which might be connected with it. If we conceive the physical conditions on which organic life depends to have changed, beyond the range of the possible adaptation of organization, over all those parts of the earth's surface which contained a given system of life, the extinction of that system might be complete, and the history of it become part of Palæontology. Now, this which has actually happened since the creation in European seas of some of the living species of Mollusca (by the desiccation, for example, of the old sea-channel of the valley of the Danube) has occurred many times in the course of geological history, and gives, in fact, the unit of measure for the Palæozoic, Mesozoic, and Cainozoic ages of the globe. Assuming then (1), the geographical distribution of organic life to be from local centres for each species (whether one individual, one pair, or many of each species were *created*), and (2) diffusion from this centre, to go on

uniformly by germs proportioned to the number of prolific individuals, till some physical change destroys the race, we shall have the following laws of phenomena:—

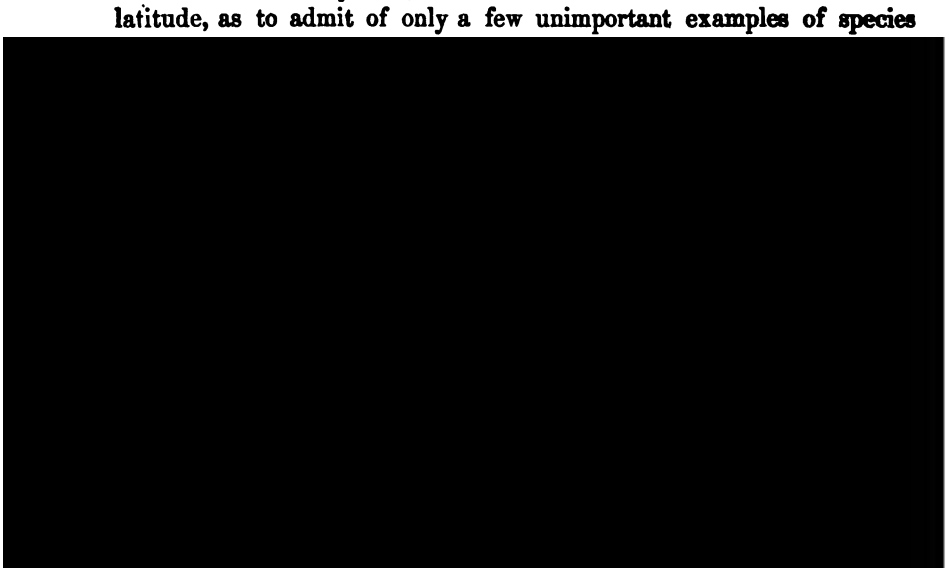
(*a.*) The area occupied by the species at any particular epoch of time, will increase uniformly in a geometrical progression, while the time increases in arithmetical progression.

(*b.*) If the germs be carried only along a narrow elongated space between parallel lines, extending indefinitely from the place of their origin, the distance which the species may reach after a given period of time, will be in proportion to the area previously occupied.

(*c.*) If the germs be carried equally in all directions from the place of their origin, the distance which the species may reach after a given period of time will be only as the square root of the area previously occupied.

Conclusions of this kind form, undoubtedly, the basis of accurate reasoning on the distribution of organic forms; but they are subject to many disturbances and exceptions, through the variety of physical agencies to which life is made subject. Fortunately for Palæontology, these variations are far less considerable in the sea than on the land; and we are able to recognise examples, both in the modern and ancient conditions of the globe, of the radial and parallel distributions of marine life, though, as might be expected, in the greater number of instances, these characters are mixed. Radial distribution may be instanced in the phenomena brought to light by the researches of Professor Forbes in the Ægean sea; for there the diffusion of species seems to be limited only by the special laws of their organization, which render certain depths and qualities of sea bed proper for certain races.

Dr. Richardson regards the distribution of fish in the warm seas from Africa to Polynesia, as of so uniform a character over 60° of latitude, as to admit of only a few unimportant examples of species



M. Alcide D'Orbigny supplies us with examples of linear distribution of mollusca, by the action of marine currents along the coasts of South America. This mass of land so effectually divides the fauna of the Atlantic from that of the Pacific, that out of 362 species which occur along the South American coasts, 156 are peculiar to the Eastern, 205 to the Western shores, and only one common to both the Atlantic and the Pacific waters. In both of these oceans general currents, sweeping upward from the southern regions toward the equator, carry the littoral Mollusca through many degrees of latitude, and through several zones of heat. Twelve species are thus transported in the Atlantic over 19° of latitude, ceasing to exist about the line of the tropic on the coast of Brazil; and in the Pacific 15 species are carried through 22° of latitude, and terminate with the currents north of Callao.

The Gulf stream is, perhaps, the agent of distribution, by which Brazilian forms of fishes are carried northward to the coasts of the United States, and even as far as the banks of Newfoundland. Thus we have in the Atlantic the general dependence of organic life on temperature overcome by the influence of currents, which in the southern hemisphere carry species to warmer, and in the northern to colder habitats; a circumstance very worthy of the attention of geologists.

Even in the restricted area of Palæozoic strata which has been examined by the Geological Survey, we perceive the two kinds of distribution. In the eastern region, the districts of Malvern, Woolhope, Mayhill, &c., present so nearly the same organic forms as the strata of Ludlow, associated in the same order, as to imply dispersion in all directions in a limited basin, while from St. Bride's Bay to Builth, and even to Usk, we seem to trace the agency of a sea current, sweeping from west to east into this basin, and bringing to it a peculiar suite of littoral shells, constituting the very latest traces of the Silurian life.

According to the views which have been already stated, the distribution of life from a centre in the sea, might equally produce sheets or strata of organic exuviæ, but very unequally; in the one case wide areas, in the other long narrow spaces of uniform life. These sheets of exuviæ, covered up with sand or mud, might constitute a geological deposit or set of deposits, characterized by peculiar suites of organic remains, but the distant parts of a deposit *could not be strictly contemporaneous.* The parts near the centre of life would be older, those at the extremity younger; and, if (which is probable) the mineral deposit might be brought by the same current which carried the organic forms, the deposit might present a wedge-like form, thicker and of coarser grain toward the origin of the current, and attenuated toward the extremity. It might also happen, that the organic exuviæ should be accumulated

more abundantly, or in more numerous layers, toward the centre of life than toward the extremity.

From these considerations it appears to follow, 1. That littoral Mollusca, as being dispersed by narrow and strong currents, are more rapidly distributed than the deep-sea tribes; 2. That their exuviæ in a fossil state, may be regarded as more nearly of contemporaneous deposition, and more definitive of geological time than others of pelagic habits; and 3. That by comparing the relative abundance of the shells, and the relative thickness and mineral character of the deposits, the direction of ancient currents may be known.

The distance to which the forms of life may be carried depends not only on the currents of water or air, which may tend to drift them, but also on their own organization and vital formation. Thus the elastic extrication of some seeds, the feathery parachute of others, assist in disseminating plants on land, and the ciliated apparatus of the young zoophyte or conchifer, and the finny or bladdery expansions of young mollusks, perform the same process in the sea. The perfect cephalopod may swim far from his place of birth, the gasteropod may float or crawl, and many of the conchifers exert feeble locomotive powers; but the apodal oyster, and the root-footed encrinite must, after once fixing themselves, remain attached for life. The distributiveness of organic forms (as the measure of this quality may be termed) is found to be very unequal, * and will require particular attention in our subsequent inquiries.

The districts to which it is proposed to refer the several localities of fossils, are 13 in number, viz.:—

Cardigan,
Marloes,
Freshwater,
Haverfordwest.

ON THE GEOLOGICAL DISTRIBUTION OF THE LOWER PALÆOZOIC LIFE.

The strata in which these remains occur consist of conglomerates, coarse and fine sandstones, sandy and argillaceous shales, and argillaceous and pure limestones, constituting altogether a series of deposits from 2000 to 10,000 or more feet in thickness; they constitute the Silurian system of Sir R. I. Murchison; the total thickness varies in the different districts. The series is in several countries distinctly divided into two portions, which have been termed by Sir R. I. Murchison "Upper" and "Lower Silurians," these latter being included by Professor Sedgwick in his great group of (Cambrian) strata. Sir H. T. De la Beche has furnished measured sections of these rocks in all the districts now to be noticed.*

No district yet discovered exhibits all the Silurian formations in full development, but by combining the information furnished from the eastern border of Wales (Salop, Hereford, &c.) by Sir R. I. Murchison, with that gathered on the southern border by the geological survey, and in North Wales by Sedgwick, the following general classification is obtained:—

Arenaceous group of Downton and Ludlow.
Calcareo-argillaceous group of Woolhope forest.
Arenaceous group of the Caradoc hills.
Calcareo-argillaceous group of Llandilo.
Lowest arenaceous and argillaceous groups of North Wales.

Within the district under consideration the two lowest of these groups are best exhibited in the western parts, the three upper groups in the eastern parts; in the intervening spaces intermediate characters of stratification occur.

The western parts of South Wales contain types of stratification and suites of fossils, analogous in many respects to those of North Wales; the region of Malvern, Woolhope, &c., corresponds still more exactly with the Salopian series already described as the Silurian type by Sir R. I. Murchison. In many respects the eastern district deserves this distinction; for here principally the calcareous element of the series is developed, and with it a variety of organisms, which are elsewhere absent or of rare occurrence. In proceeding south-westward from this region the upper limestone bands become attenuated and lost; and with them the distinctness of the several sub-divisions of the series, and many groups of fossils gradually disappear. It is then found no longer possible to apply the limited rules for distinguishing the strata by peculiar fossils, which apply so well near Ludlow and Ledbury, and it becomes

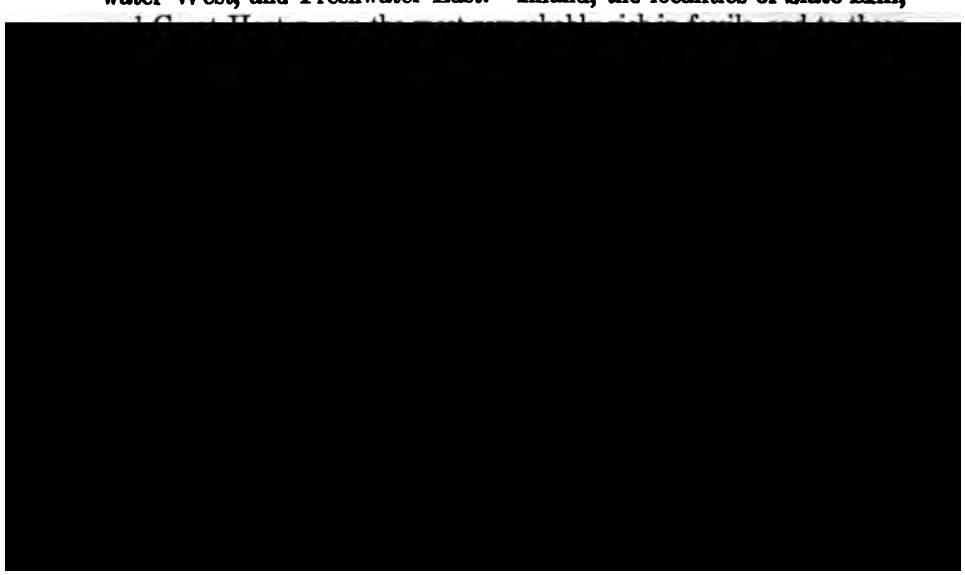
* Memoirs of the Geological Survey, vol. i. p. 20, *et seq.*

necessary to study the distribution of all the groups of organization for the discovery of more general methods.

For this purpose it is convenient generally to consider the distribution of the Silurian fossils in five great regions, according to a combination of geographical and geological characters; but sometimes it is advisable to examine the same questions more minutely by referring to the several *districts*, which have been already indicated as marks of the geographical distribution of species. The five great regions are as follow:—

Western Region, including the Districts of Marloes Bay, Freshwater, &c.	**Narberth Region, including the Districts of St. Bride's Bay, Haverfordwest, Narberth, St. Clair's, and Caermarthen.** —— **To this region may also be referred the Districts of Lampeter, Cardigan, and Fishguard.**	**Region of the Towy, including the Districts of Llandilo and Llandovery.**	**Builth Region, including Noeth Grug, Builth, and Corn y fan.**	**Malvern, or Eastern Region, including Usk, Tortworth, May Hill, Woolhope, Abberley, and Malvern.**

The western region, part of South Pembrokeshire, includes a series of detached small areas, exposed within larger surfaces of Old Red Sandstone. The strata are usually arenaceous and shaly, with some admixtures of calcareous bands. The most extensive sections are seen in the crescentic curves of Marloes Bay, the northern of which may be, for distinction, termed Wooltack Bay. The other localities of interest on the coast are Musclewick Bay, St. Ishmael's, Lindsway Bay, Freshwater West, and Freshwater East. Inland, the localities of Slate Mill,



edges of layers rich in fossils, and these more or less ferruginous. These layers, from the abundance of shells, &c., locally become impure limestone (Freshwater East). In the bay of Freshwater West, among the uppermost layers, are some thin limestone bands, containing much coral. Many organic remains in these beds, which are from 800 to 1100 feet thick.

Shale.—Group at Marloes Bay, including some thin conglomerates in Marloes Bay and thick sandstones in Wooltack Bay. The shales are, in Marloes Bay and in Lindsway Bay, interlaminated with subcalcareous layers, containing corals and encrinites. Many organic remains in these beds, which are above 500 feet thick.

Conglomerate beds of Marloes Bay.—These are seen in connexion with the trap rocks, and appear to have been formed in consequence of movements accompanying and following the eruption of those rocks. No fossils have been obtained from this set of beds, which are about 300 feet.

Black Shale of Musclewick Bay, in which are interspersed many thin subcalcareous laminæ, and near the upper part an irregular band, sufficiently calcareous to deserve the title of limestone. These are the lowest strata of the region of South Pembroke. Their thickness is unknown, but may be supposed very considerable. The four groups taken together must be at least 2000 feet thick. Indeed the two upper groups *appear* in Wooltack Bay to equal this thickness.

Under the title of the Narberth region, is included a long line of fossiliferous country between the sea at St. Bride's Bay, and a point in the Vale of Towy between Caermarthen and Llandilo. In this area Haverfordwest, Narberth, St. Clairs, and Caermarthen constitute centres of smaller districts, each offering some peculiarity of detail, but all referrible to the same general scale of stratification. To the same scale may also be referred the detached fossiliferous bands of North Pembrokeshire, about Abereiddy and Fishguard, and various localities between the River Teivy and the low country on the line of the Taaf and the Towy.

Compared with the district of South Pembroke already described, the strata of Haverfordwest, Narberth, St. Clair's, and Caermarthen appear deficient of all, or nearly all, the upper portions; while, on the other hand, the lowest part of the series is much more developed and extended over wider areas. The following is a general view of the series:—

Conglomerate of Robeston Wathen; a mass of slightly worn fragments of trap and sandstone rocks, seldom larger than an egg, lying in thick beds, and devoid, or nearly so, of organic remains. Its thickness is extremely variable, and in some parts it is untraceable. Near Caer-

marthen vast heaps of conglomerate, full of large and much rolled pebbles, appear to be associated with the trap rock there much as the conglomerates in Marloes Bay are associated with the igneous products of that region, and they are, perhaps, of contemporaneous origin.

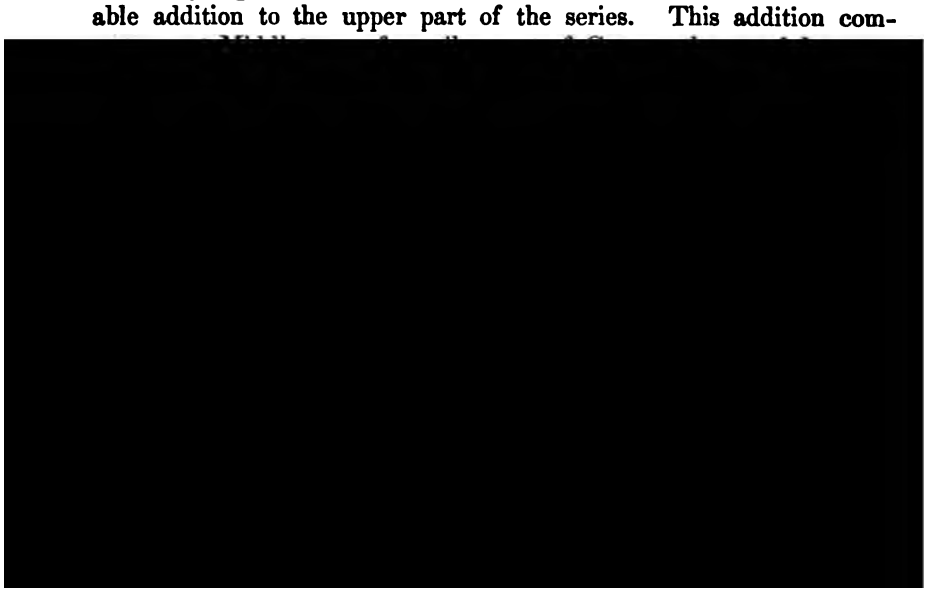
Fossiliferous shales of Robeston Wathen. Generally of a bluish gray tint, but weathering to various shades of brown by the change of oxidation of the iron. These beds are extremely rich in fossils, of many kinds, and preserve this character through the whole district, at least, in portions of their thickness. About Haverfordwest, the undulations of the beds increase their apparent thickness, which, in the hill of Robeston Wathen, is under 300 feet, and from that point augments eastwards, till, in the vicinity of Llandewi Velfrey, it amounts to 900 feet.

Limestone of Robeston Wathen and Llandewi Velfrey.—This single or double series of limestone beds, exceedingly variable in total thickness, is partly the result of coral growth (Robeston Wathen, and near Narberth), partly an accumulation of shells (Lann Mill and Clog y Fran), and in places almost devoid of any organic remains.

Black shales of Robeston Wathen and St. Clair's.—This laminated mass of argillaceous deposits, usually of a dark or black colour, and locally full of graptolites, appears generally subjacent to the whole of the limestone last noticed. But in some places, as at Crinow near Narberth, and at Llandewi Velfrey, black shales lie upon the limestone, and also contain graptolites.

In a general sense, the whole series of strata in the district, from St. Bride's Bay to a point east of Caermarthen, may be regarded as Lower Silurian.

The strata already described in the last district are continued through the Towy region, with some variations and omissions, and a remarkable addition to the upper part of the series. This addition com-



hill called Trichrug, and near the bridge of Pont ar y Llechau) there is added a more argillaceous gray series, in which a great number of beautiful fossils occur, deserving special attention. Thickness 400 feet.

Red Sandstone, without fossils, thickness 600 feet; best seen near Llangadoc.

Purple and gray conglomerates, and sandstones partially fossiliferous; best seen near Llangadoc.

Gray laminated sandstones and shales rich in fossils; well seen near Golden Grove.

Coarse rough sandstones, with fossils, at Golden Grove.

Gray laminated shales, with fossils, at Golden Grove.

Limestone of Golden Grove, with bands of shale, all more or less fossiliferous. This is followed by argillaceous shales; thick sandstones and shales; and limestones and shales, all more or less fossiliferous.

In a general sense this series may be regarded as containing peculiar types both of Upper and Lower Silurians, which cannot be clearly understood, or placed in just comparison with the other districts, till we have taken the evidence of organic remains.

In the region of Builth, the limestone part of the series of Llandilo fails; the tilestone of the same district ceases or changes its aspect and associations. But, as a compensation, the series of strata begins to assume those distinctions which fully prevail in the vicinity of Ludlow, and in the district of Malvern. The limestones of Woolhope, Wenlock, and Aymestry are, indeed, imperfectly developed, or only partially apparent, but *their places,* at least, are *determinable;* and thus, by the help of this intermediate area, the very dissimilar sections of Malvern and Llandilo become comparable in terms of geological time, and the whole line of country, from the Severn to St. Bride's Bay, capable, in some degree, of a uniform classification.

An extraordinary thickness of the Upper Ludlow deposits * is characteristic of this region, which is also remarkable for the absence of any sandstone beds really corresponding in age and mineral character with the Upper Caradoc layers of the Malvern region.

The eastern region has been already sufficiently characterized, and the relations in which it stands to the other more westerly tracts may, perhaps, be better understood by means of comparative representations of them in the order of their geographical position.

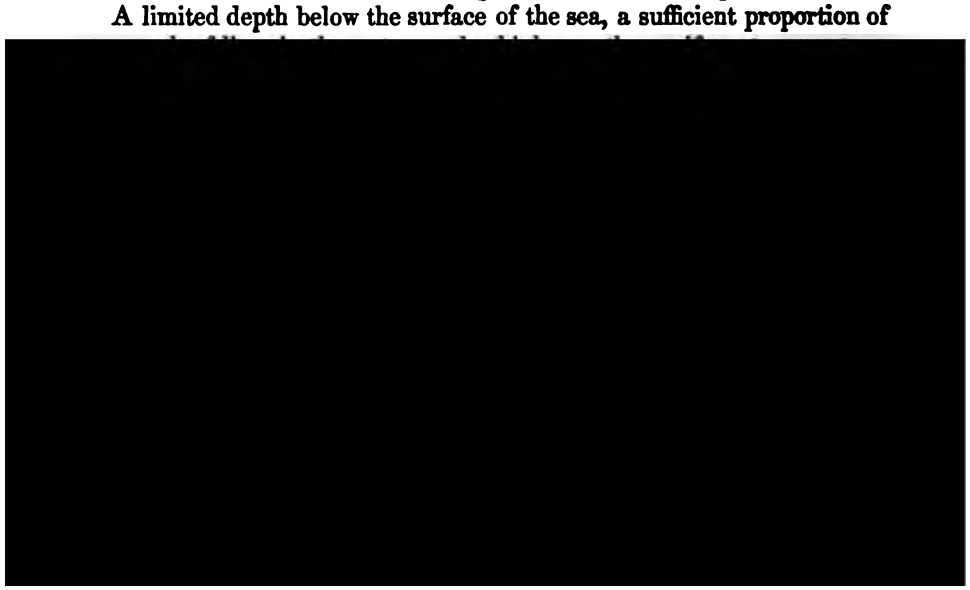
* Memoirs of the Survey, vol. i. p. 22.

ASSOCIATION OF MINERAL AND ORGANIC PHENOMENA IN THE LOWER PALÆOZOIC STRATA.

The dependence of the various classes of animal life on external physical conditions is very unequal, and varies with every particular tribe and even every single species. From the close and numerous analogies between fossil and recent organisms, we cannot doubt that the same general laws of dependence on physical conditions belong to each, and thus with suitable caution in the *application of these laws* we may often determine the probable circumstances of life of many extinct species and races of animals. By *direct observation* we may, in some cases, learn the characters of the sea bed which were more or less favourable to the development of particular groups, and, in other cases, the nature and depth of the water which surrounded them.

In the Silurian strata of the region under consideration, the most remarkable instance of this limitation of organic forms to particular accompanying conditions is furnished by the lamelliferous *corals*, and, indeed, the Zoophyta generally, which are not equally or indiscriminately scattered through the Silurian masses, but are comparatively rare in though not altogether absent from the shales, sandstones, and conglomerates, while they occur in vast abundance at certain stages of the deposition usually marked by bands of limestones. In certain cases (as at Dormington, at Aymestry, and Dudley), they constitute several beds, or even a great part of the whole calcareous mass, which may then be properly termed a 'coral reef.' In other cases, where they are less plentiful, the rock is full of remains of mollusca and crustacea; just as in the modern ocean shell beds occasionally occur in the lines of coral banks, and increase the zoological wealth of the deposit.

A limited depth below the surface of the sea, a sufficient proportion of



Retardation or interruption.	2	Woolhope coral beds.
		Sandstones and shales, with scattered corals.
(Subsidence.)		
Retardation or interruption.	1	Llandilo coral beds.
		Sandstones and shales.

To account for these facts the following two suppositions are sufficient. First, that throughout the period of time which elapsed during the production of these strata, the bed of the sea was subject to subsidence, in the whole area under consideration. Secondly, that this subsidence was interrupted or *retarded* at intervals. The consequences would be a diminution or cessation of the argillaceous and arenaceous sediments which were borne by sea currents into the sinking or depressed parts; and opportunity for the growth of Zoophyta especially, and mollusca and other invertebrata generally.

That the movements of depression, by which the accumulation of the sediments was directed to particular areas, were long continued and of a gradual character appears by the circumstance that those sediments contain many scattered corals, often ranged in lines, which may be regarded as incipient reefs, incapable of rising to much importance because of the too rapid subsidence of the sea bed. This might even furnish a rude measure of the relative times occupied in the production of growing thicknesses of shale and coralloidal limestone.

The greatest accumulation of coral is in the band No. 3, "The Wenlock Limestone," which is also the richest in shells and crustacea, and corresponds to the largest interval of interrupted or retarded subsidence.

If we now examine the geographical extent of these coral beds we shall be able to trace the area subject to the *interruptions* or *retardations* of *subsidence*—intervals of repose as they may be called. The result is remarkable. The intervals of repose were not the same throughout the Silurian district. The lowest, or Llandilo band, is hardly known towards the eastern border; the Woolhope, Wenlock, and Aymestry bands are but indistinctly exhibited toward the west.

The subsidence on the west appears to have been to a much greater depth, and if operated in the same times may be regarded as more rapid.

More rapid subsidence would probably generate more powerful sea currents and permit of their transporting sediments in greater abundance, and, in part at least, of coarser granulation, and thus might even conglomerates be occasioned. Now, these circumstances are observed to occur in all the south-western and northern regions of Wales, in Cumberland, and the Lammermuir ranges. The strata are thicker,

more abundant in arenaceous and pebbly ingredients, less rich in limestones, and less rich upon the whole in animal remains, and especially in Zoophyta.

Another consequence follows. The sea, in places thus continually loaded with sediments, was not fitted to sustain *all* the races of animals which might reside in the parts where the deposits were less copious and of a less arenaceous character, but was adapted to some additional forms. Hence it follows that the strata in Wales, which were exactly of coeval formation with those of Salop, Hereford, Gloucestershire, and Worcestershire, cannot be expected to agree with them in their imbedded fauna to the same extent that the detached deposits of Gloucester and Salop agree with each other. The numerical proportion of according forms must be less, and must vary in the different groups of animals according as these are more or less dependent on the peculiar physical conditions which are thus shown to have been different in these different regions.

The hypothesis of the non-occurrence of organic remains in certain strata by reason of the great depth of water in which they were deposited must be cautiously expressed. Such deep sea deposits are merely sediments which were drifted by currents through the *shallower* waters, and in this transport they can hardly fail to have gathered and become mixed with a variety of small or easily transported organic substances, such as the foraminifera of the chalk and oolite, and the sponges of the chalk.

The foundation of the catalogues which follow was laid in the inland quarries and sea cliffs where the fossils were collected. Very often, especially in the extreme western and extreme eastern regions, the names and localities of the specimens were entered in a journal of observations on the instant of the discovery; if this was not done, the collections were all laid out and examined by the Author at the local

the collections, however, filling more than 200 drawers, was commenced by the Author, in the rooms appropriated to the Survey in Whitehall-yard.

The region of Builth, which the Author did not personally explore, was not at first included in his plan, but was added in consequence of a communication from Mr. Salter of the localities and species which he had observed in a visit to that quarter.

The catalogues of species and localities, thus arranged, have been revised by the Palæontological department of the Geological Survey, now under the direction of Professor Edward Forbes, who has himself furnished the list of Cystideæ, the discovery of which is due to Sir H. T. De la Beche. The few vegetable remains which are noticed have been submitted to Dr. Hooker.

Mr. Salter, of this department, has not only contributed his friendly assistance in the whole of this revision, but has, in the course of it, entirely remodelled the nomenclature and weighed the claims of every species of Crustacea admitted in the catalogue. Sir H. T. De la Beche is identified with every page of this work, by personal toil in the field, by innumerable conferences and discussions on the philosophical bearings of the facts, and by a perpetual and vigilant interest in the progress of the inquiries.

It is necessary to observe, that many species known or believed to be undescribed are omitted from the catalogues, on account of some difficulty or just hesitation as to the determination of their affinities or their distribution. The new species which are admitted and described, as well as the slight changes in the nomenclature of the Silurian system which time and a reference to the works of foreign writers have rendered necessary, may, it is hoped, be relied on. Descriptions and figures of new or hitherto imperfectly discriminated species are given in the 'Palæontological Appendix.'

The numerous localities are arranged for convenient reference in the several districts; and the strata from which, at these localities, the fossils were collected, will be noticed in special lists following the catalogues of fossils. In cases where at one locality specimens were collected from several strata, the particular rock from which each was obtained is marked by abbreviations in capital letters as follows:—D. S. Downton Sandstone; U. L. Upper Ludlow; A. L. Aymestry Rock; L.L. Lower Ludlow; W.L. Wenlock Limestone; W.S. Wenlock Shale; WP.L. Woolhope Limestone; U.C. Caradoc Sandstone (or Upp. Car.); L.C. Caradoc Conglomerates (or Lower Car.)

In the western districts T.S. is put for the Tilestone; M.S. for the beds (Myddelton Series) between it and the Llandilo Flags, which are marked L.F.

FISHES.

The classification of Fishes presented by M. Agassiz admits of four orders: but of these only two have yet been found to occur in any of the Palæozoic strata. Following the mode of tabulation already adopted, we have the following comparison of the living and Silurian orders of fishes:—

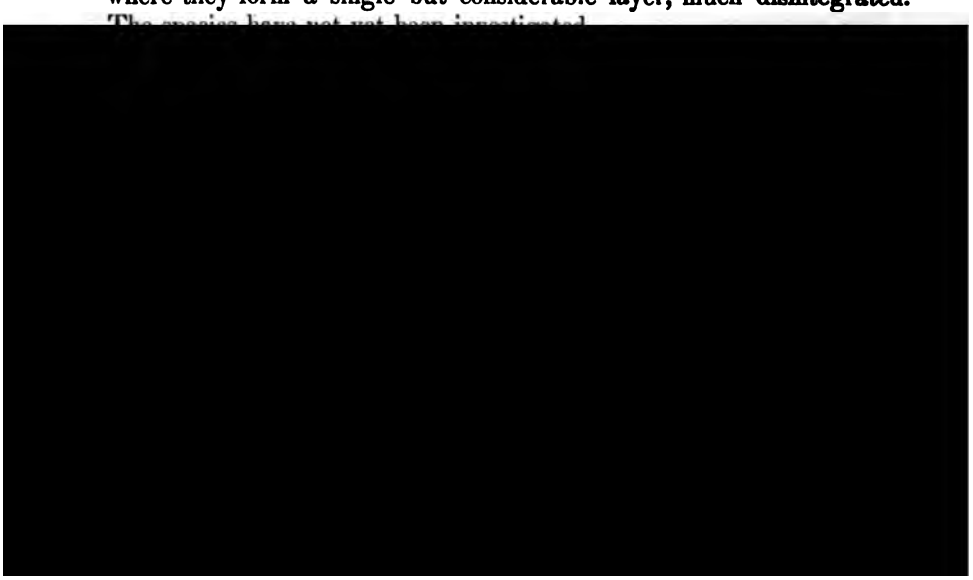
Living.	Orders.	Silurian.
Numerous . .	Cycloid Fishes .	None.
Numerous . .	Ctenoid Fishes .	None.
Few . . .	Ganoid Fishes .	Few.
Few . . .	Placoid Fishes .	Few.

There are scales, probably, of ganoid fishes at Pyrton Passage, but those most frequently met with in Silurian strata are regarded by Agassiz as of the placoid tribes. In the Malvern district we have found

Onchus Murchisoni,
——— tenuistriatus,
——— ns. decorus,
} In Upper Ludlow, near Mathon Lodge, and at Hales End.

In the localities named the remains of fishes may be traced downward in the strata to the surface of the Aymestry rock, but only faint and unsatisfactory indications of ichthyoid fossils have been noticed below that parallel, in any part of the Malvern or Abberley hills.

In the district of Woolhope and May Hill I found fish remains only in the uppermost beds of the Ludlow rocks, in the vicinity of Higford, where they form a single but considerable layer, much disintegrated. The species have not yet been investigated.



living nature, the placoid fishes commonly attain. It must be owned, however, that our information concerning them is very imperfect, and like the specimens, merely in fragments. We shall build no geological inferences on so imperfect a basis.

ANNELIDA.

Dividing the Annelida with Cuvier into three orders mainly characterized by the situation of their branchial organs, we have the following general comparison of the living and Silurian tribes :—

Living.	Orders.	Silurian.
Many .	Dorsibranchiata . .	Few.
Many .	Cephalobranchiata .	Several.
Many .	Enterobranchiata .	One?

The most numerous of the fossil groups of Palæozoic annelida—the tubicolar, or cephalobranchiate tribe—is recognised in all the systems of strata. It is only in one Silurian district of Great Britain that we find any positive trace of the wandering, or dorsibranchiate races. Captain Portlock conjecturally refers to this division certain spicular forms from the Silurian schists of Fermanagh ('Report on Tyrone,' pl. xxiv., fig. 8). Cornulites and tentaculites were first included among the annelida by Mr. Salter ('Reports of the British Association for 1845').

Following the arrangement proposed by Mac Leay ('Sil. Syst.,' p. 699), the comparison will stand thus :—

Living.	Groups.	Silurian.
Many .	Nereidina . .	Few.
Many .	Serpulina . .	Few.
Many .	Lumbricina. .	Few.
Few. .	Nemertina . .	One?
Several .	Hirudina . . .	None.

The classification of Audouin and Edwards is in principle nearly identical with Cuvier's.

DORSIBRANCHIATA, Auct. ANNELIDA ERRANTIA, Audouin and Edwards. NEREIDINA, Mac Leay.

NEREITES CAMBRENSIS, Mac Leay.

REF.—Murchison, Sil. Syst., pl. xxvii. fig. 1.

Cardigan District . . Lampeter; in rocks regarded by Sir R. I. Murchison in 1836 as below the Llandilo series of strata.

NEREITES SEDGWICKII, Mac Leay.

REF.—Murchison, Sil. Syst., pl. xxvii. fig. 2.

Cardigan District . . Lampeter.

MYRIANITES MAC LEAYII, Murchison.

REF.—Murchison, Sil. Syst., pl. xxvii. fig. 3.

Cardigan District . . Lampeter.

CEPHALOBRANCHIATA, Auct. ANNELIDA TUBICOLA of Cuvier, Audouin, and Edwards. SERPULINA, Mac Leay.

SPIRORBIS LEWISII, Sowerby.

REF.—Murchison, Sil. Syst., pl. viii. fig. 1.

Builth District . . . Pwll ddu.

SERPULITES LONGISSIMUS, Sowerby.

REF.—Murchison, Sil. System, pl. v. fig. 1.

Observation.—Under the microscope the shell shows a uniform dense texture without cells.

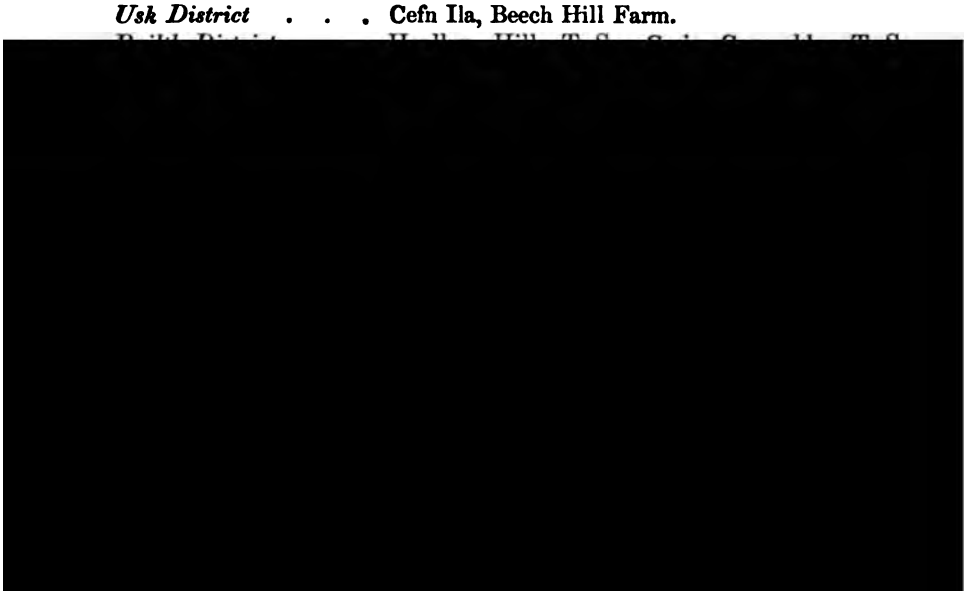
Malvern District . . Pound, Combe Hill, Frith Farm, Hall Court, Mathon Lodge, Overley, Brock Hill.

Abberley District . . Barrell Hill, Walgrove Hill, Hole Farm, Hill End, Ankerdine Hill.

Woolhope District . . Wonder, Pilliard's Barn, Putley, South of Hazle, Welsh Court.

May Hill District . . South-west of Hobbs.

Usk District . . . Cefn Ila, Beech Hill Farm.



Abberley District . . Walgrove Hill, U. L., Hole Farm, U. L., Callow Farm, Hill End, U. L.
Woolhope District . . Putley, Hazle, Ecknall Copse, Dormington Wood Littlehope.
Tortworth District . . Whitfield, Horse Shoe Farm.
Usk District . . . Llanfrechfa, Llangibby Castle, Bryn Graig, Pres coed.
Builth District . . . Craig Pwll ddu, U. L., Craig Cwm ddu, L. L.
Llandilo District . . Swansea Road (4 and 6). Dafaddfa Uchaf. Storm Hill Lodge, Cilwaun.
Allt ddu. Coed Sion. Middleton Hall. Nelson's Tower Wood.
Haverfordwest District. Llandowror. Cnwc. Great Creswell.
Marloes District . . Marloes Bay, 3a. Hooton, St. Ishmael's. Lindsway, Wooltack.

TENTACULITES {ANNULATUS, SCALARIS,} Schlotheim.

REF.—Schlotheim. Petref., t. xxix., fig. 8, 9. Murchison, Sil. Syst., pl. xix., fig. 15, 16.

Observation.—According to Mr. Salter, the latter of these supposed species is but the internal cast of the former.

Malvern District . . Gunwick Mill, Worcester Beacon, U. C., Eastnor Obelisk.
Abberley District . . Ankerdine Hill, U. C.
May Hill District . . Huntley Hill.
Tortworth District . . Charfield Green.
Usk District . . . Cefn Ila.
Llandilo District . . Cilwaun, Keeper's Lodge? Golden Grove.
Haverfordwest District. Priory Mill, Shole's Hook, Ben Lomond Cottage, Robeston Wathen, above L. F.
Freshwater District . Freshwater East (South side of Bay).
Marloes District . . Marloes Bay, Hooton, St. Ishmael, Lindsway.

TENTACULITES TENUIS, Sowerby.

REF.—Murchison, Sil. Syst., pl. v., fig. 33.

Malvern District . . Halesend, U. L., Pound.
Woolhope District . . Shucknall Farm.
Usk District . . . Llanfrechfa.

TENTACULITES ORNATUS? Sowerby.

REF.—Murchison, Sil. Syst., pl. xii., fig. 25.

Abberley District . . Abberley Lodge, Callow Farm.
Tortworth District . . Horse Shoe Farm.
Usk District . . . Bryn Graig, Darren, Usk Castle, Llanbadoc.
Llandilo District . . Bird's Hill Quarry (by Dynevor Park).

TRACHYDERMA, Phillips. New genus.
(τραχυς, rough, δερμα, skin.)

Nearly all the annelida of the Palæozoic strata which have hitherto been described were fabricators of shelly tubes. The occurrence of the squamose rather than shelly tube, to which the above name is now applied, is very unfrequent. It is very different from the cololitic forms to which Portlock applies the name of Lumbricaria ('Report on Tyrone,' &c., pl. xxiv. fig. 7). It belongs probably to the cephalobranchiate order.

TRACHYDERMA SQUAMOSA, Phillips.

REF.—Palæontological Appendix.

Malvern District . . Brockhill, Dog Hill.
Woolhope District . . Backbury Camp, Shucknall Farm, Bodenham Quarry, Gorstley, near Newent.

TRACHYDERMA CORIACEA, Phillips.

REF.—Palæontological Appendix.

Abberley District . . Hill Side Farm.

ENTEROBRANCHIATA, Auct. NEMERTINA, Mac Leay.

NEMERTITES OLIVANTII, Mac Leay.

REF.—Murchison, Sil. Syst., pl. xxvii., fig. 4.

Llandilo District . . Lampeter.

From the data which have been thus collected the following table, showing the geographical distribution of each species, is constructed. The numbers along the horizontal line of each species mark the number of ascertained occurrences of that species in the several districts respectively. The maximum is indicated by †.

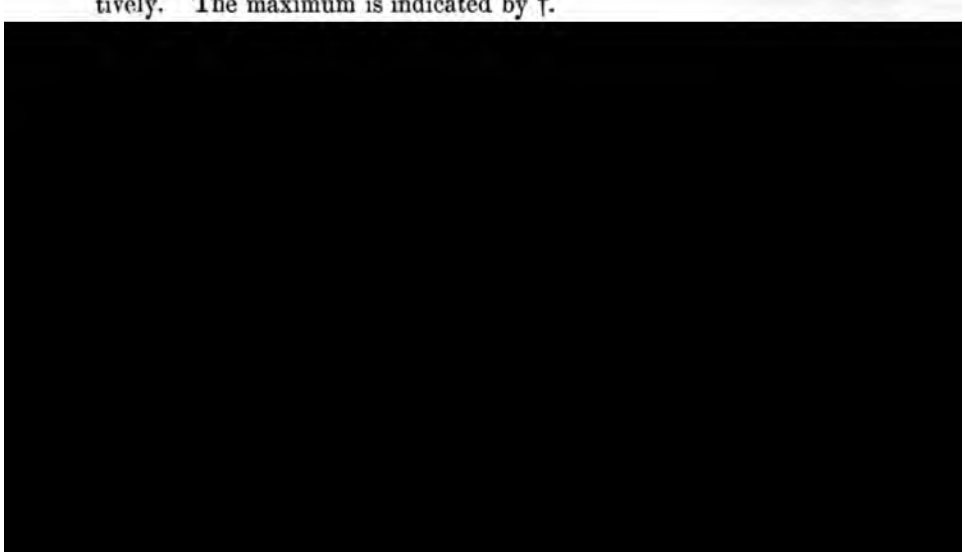


TABLE I.—*Geographical Distribution of Annelida.*

Names of Species.	Western Districts.							Eastern Districts.						No. of Occurrences of each Species.	No. of Districts in which each Species occurs.
	Cardigan.	Marloes.	Freshwater.	Haverfordwest.	Caermarthen.	Llandilo.	Builth.	Usk.	Tortworth.	May Hill.	Woolhope.	Abberley.	Malvern.		
Nereites Cambrensis	1	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Nereites Sedgwickii	1	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Myrianites Macleayii	1	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Spirorbis Lewisii .	..	..	..	..	..	..	1	..	..	..	..	..	..	1	1
Serpulites longissimus	..	..	..	..	..	..	3	2	..	1	5	5	7	23	6
Serpulites curtus .	..	..	..	..	..	..	..	..	..	..	1	2	..	3	3
Cornulites serpularius	..	5	..	3	..	9	2	4	2	..	5	4	5	39†	9
Tentaculites annulatus	..	4	1	4	..	3	..	1	1	1	..	1	3	19	9
Tentaculites tenuis	..	..	..	..	..	..	..	1	..	.	1	..	2	4	3
Tentaculites ornatus	..	..	..	..	..	1	..	5	1	..	..	2	..	9	4
Trachyderma squamosa . .	..	..	..	..	..	..	..	..	..	..	4	..	2	6	2
Trachyderma coriacea	..	..	..	..	..	..	..	..	..	..	..	1	..	1	1
Nemertites olivantii	1	..	..	..	..	..	..	..	..	..	..	..	..	1	1
No. of occurrences in each district . .	4	10	1	7	0	12	6	12	5	2	15	10	19	..	..
No. of species in each district . . .	4	2	1	2	0	3	3	3	3	2	4	5	9	..	..
	Total of species . . 13							Total of occurrences 109							

Hence it appears that *Cornulites serpularius* is the most frequently observed species of Palæozoic annelida; it has also a very wide distribution, from west (Marloes Bay) to east (Malvern).

Tentaculites annulatus, next in order of frequency, has an equal geographical range.

Serpulites longissimus, which is very often observed, has, on the

contrary, a very limited distribution westward, *ceasing* perhaps with the eastward types of stratification.

Nereites and *Nemertites* belong to one district and to one locality.

On an average the eastern districts yield annelida almost twice as frequently as the western.

We may now consider the geological distribution of these annelida.

TABLE II.—*Geological Distribution of Annelida in the Eastern Region.*

STRATA IN DESCENDING ORDER.	Serpulites longissimus.	Serpulites curtus.	Cornulites serpularius.	Tentaculites annulatus.	Tentaculites tenuis.	Tentaculites ornatus.	Trachyderma squamosa.	Trachyderma coriacea.	No. of Species in each Stratum.	No. of Occurrences in each Stratum.
12. Downton sandstone, D. S.	..	..	..	..	..	..	..	..	..	..
11. Upper Ludlow, U. L. . .	20	..	11	1	4	3	6	1	7	46
10. Aymestry limestone, A. L.	..	..	..	..	..	..	..	..	..	..
9. Lower Ludlow, L. L. . .	..	1	..	..	..	..	..	..	1	1
8. Wenlock limestone, W. L.	..	..	4	..	..	2	..	..	2	6
7. Wenlock shale, W. S. . .	..	1	2	..	..	1	..	..	3	4
6. Woolhope limestone, WP. L.	..	..	1	..	..	..	..	..	1	1
5. Upper Caradoc, U. C. . .	..	..	2*	5	..	*	..	..	2 or 3	7 or 9
4. Lower Caradoc, L. C. . .	..	..	..	1	..	..	..	..	1	1
3. Trap beds	..	..	..	..	..	..	..	..	..	..
2. Black shale	..	..	..	..	..	..	..	..	..	..
1. Sandstone	..	..	..	..	..	..	..	..	..	..

* The species thus marked occur also at Horse Shoe Farm, in the Tortworth district.

Here we perceive that *Cornulites serpularius* and *Tentaculites annulatus*, which have the widest *geographical range*, have also the longest *geological duration*. No species has yet been found below the Lower Caradoc beds of Malvern.

The Upper Ludlow formation is by far the richest in annelida; no

Upper and Lower Ludlow; and *Spirorbis Lewisii*, which has not yet been observed in the eastern region, occurs in the Upper Ludlow.

In the Towy region *Serpulites longissimus* fails; *Tentaculites ornatus* occurs as low down as the limestone of Dynevor Park; *Tentaculites annulatus* occurs in the uppermost Silurian, or tilestone beds; *Cornulites serpularius* in the tilestone beds and Ludlow beds about Golden Grove, and above the Llandilo flags (L. F.) at Coed Sion, near Llangadoc.

The two species last mentioned are the only ones which extend through the Narberth and Marloes regions, occurring there, but not very plentifully, in various strata above the Llandilo limestones.

Nereites Cambrensis, *N. Sedgwickii*, and *Nemertites Olivantii*, can hardly be made the subject of discussion under this head, as they have been seen at only one locality. They occur in what may be called Lower Llandilo flags.

Generally speaking, the Silurian annelida cannot be much depended on for indicating through sections of strata, made in remote districts, lines of geological contemporaneity. Those which appear peculiar to one geological era (as *Serpulites longissimus*) have only a limited distribution; and those which have a wide distribution are found to range through a long succession of deposits. We may, however, admit a numerical increase of the annelida as we pass upwards in the Silurian groups, the maximum being at or near their upper surface.

CRUSTACEA.

The contrast is great between the subjoined lists of living and fossil crustacean orders, arranged according to Milne Edwards.

Living.	Orders.	Silurian.
Abundant . .	Decapoda . . .	None.
Several . . .	Stomapoda . .	
Few . . .	Lœmodipoda . .	None.
Many . . .	Amphipoda . .	
Abundant . .	Isopoda . . .	
None . . .	Trilobitida . .	Abundant.
Few . . .	Phyllopoda . .	None.
Few . . .	Cladocera . . .	
Few . . .	Ostracoda . . .	Few.
Few . . .	Copepoda . . .	None.
Several . . .	Siphonostomata .	None.
Several . . .	Lerneida . . .	
Few . . .	Pycnogonida . .	
Few . . .	Xiphosura . .	None.

It appears that none of the orders usually classed as of highest organization occur in the Silurian strata, and that the Crustacea most abundant therein belong to tribes which are now extinct. To what group Pterygotus is referrible seems doubtful.

The Trilobites cannot be fairly included in any one of the numerous orders established among living Crustacea by modern naturalists, but their limited analogy to Isopoda (Serolis), and their agreement in some points with the Xiphosurida (Limulus) and Phyllopoda (Apus and Branchipus), have been noticed by many writers.

Mac Leay (Sil. Syst., p. 666) places the Trilobites as one of the three orders of the great Aberrant group, Edriopthalma; between Amphipoda (including Isopoda) and Entomostraca.

The conclusion of Milne Edwards, that the Trilobites constitute a peculiar extinct series, which he places between the Isopoda and the Phyllopoda, is adopted by Emmerich, one of the latest writers on Trilobites (see Taylor's 'Scientific Memoirs,' vol. iv.).

Burmeister regards Trilobites as specially allied to Branchipus (see 'Translation of Burmeister's work by the Ray Society, 1847').

Order—OSTRACODA.

Family—CYTHERINIDÆ.

BEYRICHIA COMPLICATA, Salter.

REF.—Palæontological Appendix.

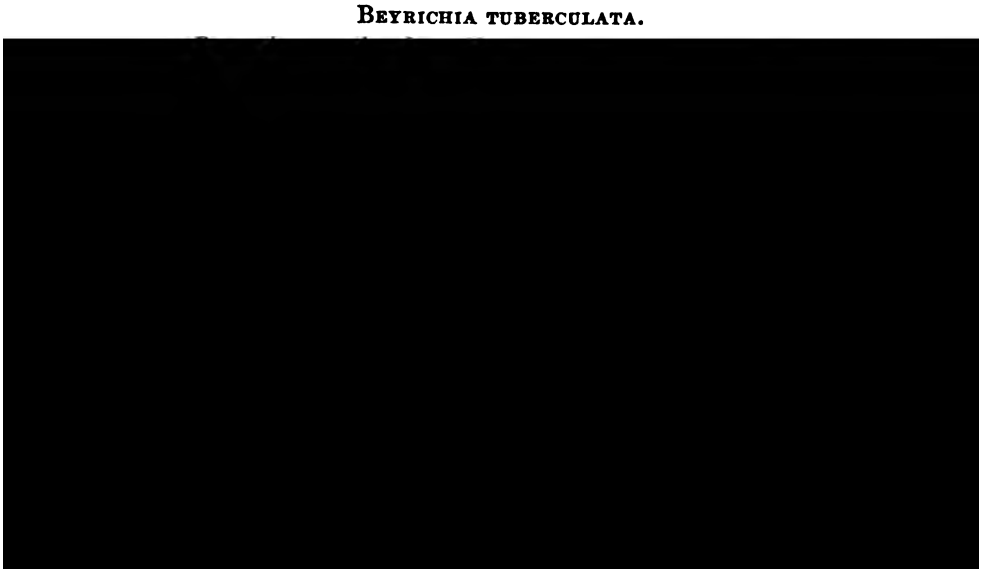
Llandilo District . . Llwych glyn. Dynevor Park.
Haverfordwest District . Lann Mill. Ciln Park.

BEYRICHIA GIBBOSA, Salter.

REF.—Palæontological Appendix.

Marloes District . . Slate Mill. Marloes Bay.

BEYRICHIA TUBERCULATA.



Malvern District . . Bason Court Farm.
Usk District . . . Upper Ludlow beds.
Abberley District . . Hole Farm, L.L.
Woolhope District . . In Upper Ludlow.
Builth District . . . In the Tilestone, two species.

Order—TRILOBITIDA.

The genera of Trilobites are becoming settled, but authors are not yet agreed upon the mode or principle of grouping them into families. Emmerich attaches special importance to the variations of the organs of vision; Burmeister to the power of rolling the body on its transverse axis; Quenstedt to the number of segments; Edwards looks at the general analogies. The classifications which result have little accordance. In the following pages the Trilobites are regarded as one great group, and the genera which we adopt are ranged alphabetically.

ACIDASPIS BISPINOSUS.

REF.—M'Coy, Syn. Sil. Foss. Irel. pl. iv. fig. 7.

Abberley District . . Callow Farm.

ACIDASPIS BRIGHTII.

REF.—Murchison, Sil. Syst., t. 14, f. 15; and *Paradoxides 4-mucronatus*, Sil. Syst., t. 14, f. 10.

Malvern District . . Ledbury.
Abberley District . . Hill End, W.L.
Tortworth District . . Skeay's Quarry (w).
Usk District . . . Llangibby, L.L. Tucking Mill.
Llandilo District . . Effynant.
Haverfordwest District . Llandowror.

AGNOSTUS PISIFORMIS.

REF.—Brongniart, t. 4, f. 4. Murchison, Sil. Syst., t. 25 f. 6 a b.

Builth District . . . Near Builth.
Llandilo District . . Near Llandilo.

AGNOSTUS TRINODUS, Salter.

REF.—*Trinodus agnostiformis*, M'Coy, pl. iv. f. 3. Palæontological Appendix.

Haverfordwest District. Pelcombe Cross. Shole's Hook.

AMPYX NUDUS.

REF.—*Trinucleus nudus*, Murchison, Sil. Syst., t. 23, fig. 5.

Builth District . . . Near Builth.
(*Gilvera H.* near Llandrindod, Murchison.)

AMPYX PARVULUS, Forbes.

REF.—Palæontological Appendix.

Abberley District . . Collins' Green.

ASAPHUS TYRANNUS.

REF.—Murchison, Sil. Syst., t. 24, t. 25, fig. 1.

Malvern District . . Under Worcester Beacon, U.C. In conglomerate of ditto, U.C.

Abberley District . . Ankerdine Hill, U.C.
Llandilo District . . Golden Grove, 1. Capel Dewi. Llandilo. Penllwynan. Penygoylan.
Haverfordwest District. Shole's Hook. Moor. Lann Mill. Ciln Park. Lampeter Hill. Robeston Wathen, L. F. Mydrim.
Marloes District . . Musclewick Bay.

CALYMENE BLUMENBACHII.

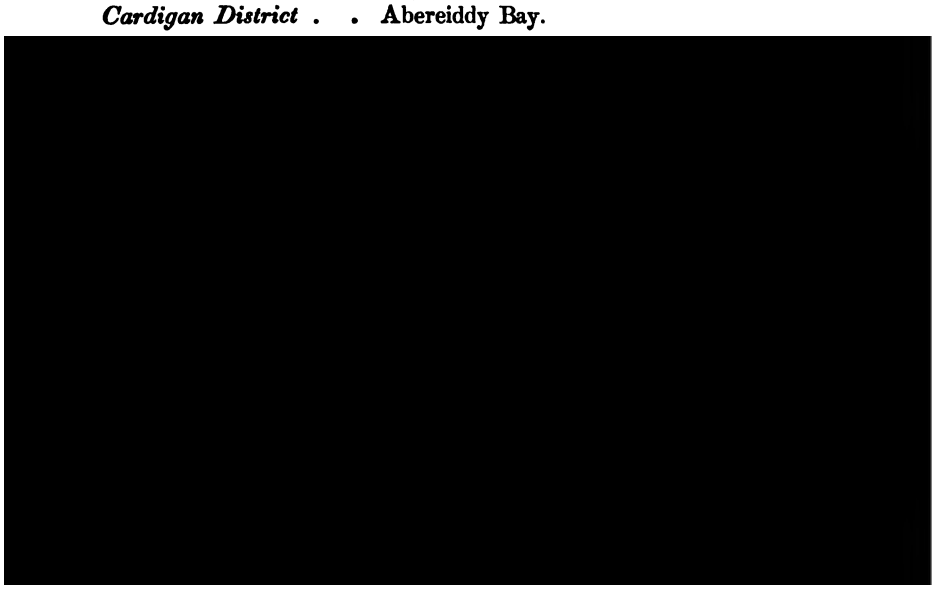
REF.—Brongniart, Crust. Foss., t. 1, f. 1. Murchison, Sil. Syst., t. 7, f. 5—7.

Malvern District . . Eastnor, Ledbury. Awkbridge Farm. Pound.
Abberley District . . Bason Court Farm. Hill End, W.L. Abberley Lodge, Callow Farm.
Woolhope District . . South of Hazle. Prior's Court. Pilliard's Barn. Backbury. East of Canwood.
May Hill District . . Taynton. The Rock. West of Rock Farm.
Tortworth District . . Horse Shoe Farm.
Usk District . . . Llangibby, L.L. Usk Castle. Bryn graig.
Builth District . . . Cwm Craig ddu, L.L.
Llandilo District . . Swansea Road, 4. Goleugoed. Cerrig gwynion. Tynewydd. Coed Sion. Effynant. Dafaddfa Uchaf, South. Golden Grove, 4. Golden Grove (Keeper's Lodge). Storm Hill. Nelson's Tower Wood. Cnwc.
Marloes District . . Slate Mill. Marloes Bay. C.D. Great Hooton.

CALYMENE BREVICAPITATA.

REF.—Portlock, Geol. Rep., t. 3, f. 3.

Llandilo District . . Dynevor. Golden Grove, 1.
Haverfordwest District. Pant Dwfn. Lann Mill. Llandowror. Pelcombe Cross. Priory Mill. Robeston Wathen, (above L.) Shole's Hook. Ciln Park.
Cardigan District . . Abereiddy Bay.



CYBELE PUNCTATA.

REF.—*Calymene punctata*, Brongniart, Crust. Foss., Murchison, Sil. Syst., t. 23, f. 8. *Encrinurus punctatus*, Emmerich. *Calym. variolaris*, Brongn. t. 1, f. 3, A.

Malvern District . . Near Worcester Beacon. U.C. Under ditto in conglomerate.
Woolhope District . . Pilliard's Barn. Road to Hazle.
May Hill District . . May Hill.
Tortworth District . . Long's Quarry, Charfield Green.
Usk District . . . Craig y garcyd.
Builth District . . Cwm craig ddu, U.L.
Llandilo District . . Castell Craig gwyddon. Keeper's Lodge (Golden Grove). Middleton Park Quarry.
Haverfordwest District . Rosemarket.
Marloes District . . Marloes Bay, E.

CYBELE SEXCOSTATA, Salter.

REF.—Palæontological Appendix.

Haverfordwest District . Shole's Hook.

CYBELE VARIOLARIS.

REF.—*Calymene variolaris*, Brongniart, Crust. Foss., t. 1, f. 3, B. Murchison, Sil. Syst., t. 14, f. 1. Palæontological Appendix.

Abberley District . . Hill End, W.L. Abberley Lodge. Callow Farm.
Woolhope District . . Dormington Wood. Pilliard's Barn.
Usk District . . . Usk Castle, Llangibby, A.L. Craig y garcyd. Beech Hill Road. Cilorgyr.
Haverfordwest District . Llandowror.
Marloes District . . Hooton.

CYBELE VERRUCOSA.

REF.—*Calymene verrucosa*, Dalm. Löven in Stockholm Proceed., 1845. Tab. 1, f. 5.

Llandilo District . . Bird's Hill. Penllwynan. Grug.
Haverfordwest District . Llandowror. Shole's Hook. Pelcombe Cross.

DALMANNIA AFFINIS, Salter.

REF.—Palæontological Appendix.

Llandilo District . . Golden Grove?
Haverfordwest District . Llandowror. Great Creswell?

DALMANNIA CAUDATA.

REF.—Brongniart, Crust. Foss., t. 2, f. 4, A—D. Murchison, Sil. Syst., t. 7, f. 8.

Malvern District . . Eastnor Castle. Eastnor Park. Dog Hill. Rilbury. Clincher's Mill. Gold Hill Farm. Awkbridge Farm. Upper Mitchell. Storridge, WP.L. Brock Hill.
Abberley District . . Walgrove Hill, A.L. Hill End, W.L. Hole Farm, L.L. Ridge Hill. Collins' Green. Abberley Lodge. Martley (road). Ankerdine Hill, U.C.
Woolhope District . . Littlehope. East of Canwood. Bodenham Quarry. Shucknall Hill. Backbury Camp. Welshcourt. North of Canwood. Checkley Common.

May Hill District . . Huntley Hill. North of Taynton.
Tortworth District . . Horse Shoe Farm.
Usk District . . . Usk Castle. Beech Hill. West of Llangibby. Craig y Garcyd. Cefn Ila Lodge. Llanbaddoc. Radyr. Cilorgyr. Ty Newydd. Trostra.
Llandilo District . . Rhiw-rhwych (North of Llandovery). Cefn Llwydlo. Swansea Road, 4. Dynevor Park. Golden Grove, 4. 2. Allt Ddu . . Cilgaun Brook. Cnwc. Middleton Park.
Haverfordwest District . Narberth.
Marloes District . . Marloes Bay, I. Wooltack Bay. Marloes Mill.

DALMANNIA LONGICAUDATA.

REF.—Murchison, Sil. Syst., t. 14, f. 11—14.

Malvern District . . Eastnor.
Abberley District . . Hole Farm, L.L.
Usk District . . . Tygoch. Tucking Mill. Craig y Garcyd. Bryn Craig. The Darran. Dowlas. Usk Castle.
Marloes District . . Marloes Bay, D. St. Ishmael's.

HOMALONOTUS KNIGHTII.

REF.—König, Icon. Sect., f. 65. Murchison, Sil. Syst., t. 7, f. 1, 2. (Includes *H. Ludensis*, Murch., t. 7, f. 3, 4.)

Malvern District . . Frith Farm. Eastnor Castle.
Usk District . . . Cock Wood.
Llandilo District . . Golden Grove, 4.
Freshwater District . Freshwater East, S.
Marloes District . . Wooltack. Marloes Bay, C. St. Ishmael's. Lindsway.

ILLÆNUS BARRIENSIS.

REF.—*Bumastus Barriensis*, Murchison, Sil. Syst., t. 7, *bis* f. 3; t. 14, f. 7.

Malvern District . . Brand Lodge.
Woolhope District . . Little Hope. Woolhope. Dormington Wood.

LICHAS LAXATUS.

REF.—M'Coy, pl. iv. fig. 9. *Calym. forcipata* (tail), *ib.* f. 14.

Llandilo District . . Keeper's Lodge (Golden Grove).
Haverfordwest District . Shole's Hook.

OGYGIA BUCHII.

REF.—*Asaphus Buchii*, Brongniart, t. 2, f. 2, A—C. Murchison, Sil. Syst., t. 7, f. 8.

Builth District . . . Builth.
Llandilo District . . Pen y goylan. N. E. of Cerrig Cegyn. Llandilo. Capel Dewi. Penllwynan, Garnllwyn.
Marloes District . . Musclewick Bay.

OGYGIA DILATATA.

REF.—*Asaphus dilatatus*, Dalman, Tab. iii. f. 1. Portlock, Geol. Rep., t. 24, f. 3.
NOTE.—*Asaphus Corndensis* of the Sil. Syst., t. 25, f. 4, resembles this species, but is distinct.

Builth District . . . Carneddau, Builth.

OGYGIA MURCHISONÆ.

REF.—Murchison, Sil. Syst., t. 25, f. 3.

Caermarthen District . ("Mount Pleasant, near Caermarthen," Murchison.)

OLENUS BISULCATUS, Phillips.

REF. in this volume, p. 55, fig. 1, 2, and Palæontological Appendix.

In the black shale of Whiteleaved Oak (Malvern district).

OLENUS HUMILIS, Phillips.

REF.—Fig. 4, 5, 6, p. 55, in this Volume, and Palæontological Appendix.

In the black shale of Whiteleaved Oak.

OLENUS SPINULOSUS.

REF.—*Paradoxides spinulosus*, Brongn., pl. iv. f. 2. Burmeister, p. 71. See also fig. 3, p. 55, in this Volume, and Palæontological Appendix.

In the black shale of Whiteleaved Oak (Malvern district).

PHACOPS DOWNINGIÆ.

REF.—*Calymene Downingiæ*, Murchison, Sil. Syst., t. 14, fig. 3 a, 3 b.

Abberley District . . Ridge Hill. Hill End, W.L. Abberley Lodge. Martley (road).
Usk District . . . Glascoed Common, W.S. Bryn Craig. Craig y Garcyd.
Llandilo District . . Pont ar y llechau. Allt ddu, 5. Golden Grove, 4. 2. 3. Swansea Road, 6.
Freshwater District . Freshwater East.
Marloes District . . Marloes Bay. Slate Mill.

PHACOPS SUBCAUDATUS.

REF.—Murchison, Sil. Syst., t. 7. 10.

Freshwater District . Freshwater East.*

* Murchison mentions from this locality *Asaphus* (*Phacops*) *Cawdori*, but we have not seen it.

PHACOPS STOKESII.

REF.—*Calymene macropthalma*, Brongn. t. 1, f. 5 (not 4.) Murchison, Sil. Syst., pl. xiv. fig. 2. P. Stokesii. Milne Edw. Crust. vol. iii., 324. See Palæontological Appendix.

Malvern District . . Wall Hills.
Builth District . . . Neuadd Llwyd.

PROETUS LATIFRONS.

REF.—*Forbesia latifrons*, M'Coy, pl. iv. f. 11.

Usk District . . . Usk above the Castle.
Llandilo District . . Allt ddu, 5.

PROETUS STOKESII.

REF.—*Asaphus Stokesii*, Murchison, Sil. Syst., t. 14, f. 6. P. Stokesii. Lovën. l. c. t. 1. f. 3.

Abberley District . . Hole Farm, L.L. Hill End, U.L. Under Rosemary Rock.
Woolhope District . . Checkley Common, and S. of Dormington Wood (Wenlock shale).
Llandilo District . . Golden Grove, 4.

SPHÆREXOCHUS JUVENIS. Salter.

REF.—[*Cheirurus globosus*, Barrande Nouv. Trilob. (Supp.) de Bohême. 1846; p. 5?]

Haverfordwest District. Shole's Hook. Pelcombe Cross.

TRINUCLEUS FIMBRIATUS?

REF.—Murchison, Sil. Syst., t. 23, f. 3.

Malvern District . . In the black shale of Whiteleaved Oak.

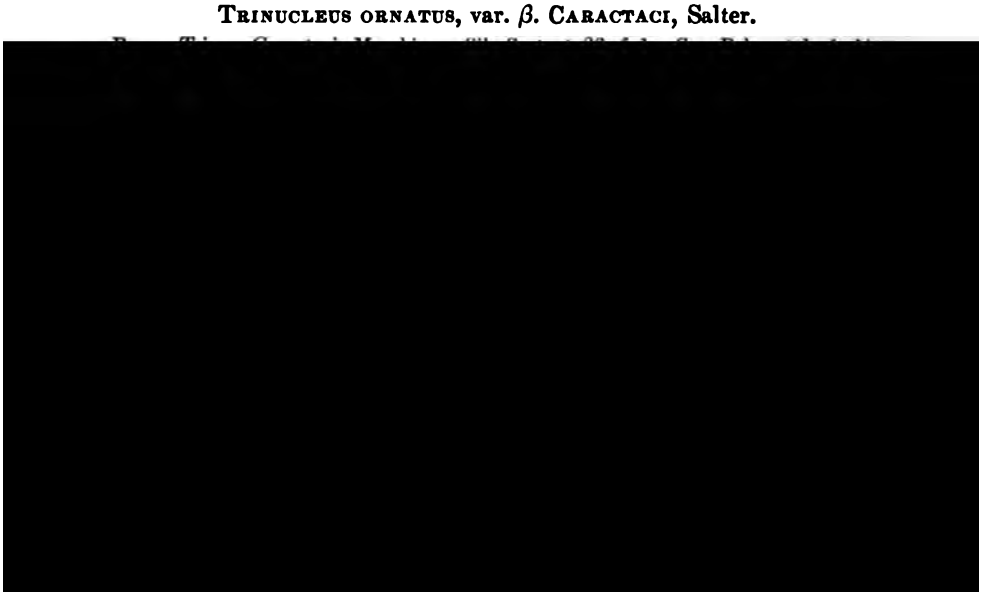
Only the radiations of the tail are distinguishable.

TRINUCLEUS GRANULATUS.

REF.—*Asaphus granulatus*, Dalman, pl. xi. f. 6.
Trin. Lloydii, Murchison, Sil. Syst, t. 23, f. 4.

Llandilo District . . Dynevor. Maerdybach. Blaen dyffryn garn, near Llangadoc.

TRINUCLEUS ORNATUS, var. β. CARACTACI, Salter.



TRINUCLEUS RADIATUS.

REF.—Murchison, Sil. Syst., t. 23, f. 3.

Llandilo District . . Drwysllwyn.

TABLE III.—*Geographical Distribution of Crustacea.*

NAMES OF SPECIES.	Western Districts.						Eastern Districts.						No. of Occurrences of each Species.	No. of Districts in which each Species occurs.
	Marloes.	Freshwater.	Haverfordwest.	Caermarthen.	Llandilo.	Builth.	Usk.	Tortworth.	May Hill.	Woolhope.	Abberley.	Malvern.		
Cytherinidæ.														
Beyrichia complicata	..	..	2	..	2	..	..	..	..	..	..	..	4	2
——— gibbosa	2	..	..	..	..	..	..	..	..	..	..	..	2	1
——— tuberculata	..	..	..	..	3	2	2	1	..	2	2	..	12	6
Cytherina	..	..	..	..	..	2	1	..	..	1	1	1	6	4
Trilobitidæ.														
Acidaspis bispinosus	..	..	..	..	..	..	..	..	..	..	1	..	1	1
——— Brightii	..	..	1	..	1	..	2	1	..	..	1	1	7	6
Agnostus pisiformis	..	..	..	..	1	1	..	..	..	..	..	..	2	2
——— trinodus	..	..	2	..	..	..	..	..	..	..	..	..	2	1
Ampyx nudus	..	..	..	..	..	1	..	..	..	..	..	..	1	1
——— parvulus	..	..	..	..	..	..	..	..	..	..	1	..	1	1
Asaphus tyrannus	..	..	7	..	5	..	..	..	..	..	..	2	14	3
Calymene Blumenbachii	3	..	..	..	12	2	3	1	3	5	4	4	37	9*
——— brevicapitata	..	..	8	..	2	..	..	..	..	..	..	..	10	2
———? duplicata	..	..	..	..	1	..	..	..	..	..	..	..	1	1
——— tuberculosa	..	..	..	..	..	..	1	..	..	..	..	..	1	1
Cheirurus speciosus	..	..	2	..	1	..	..	..	..	..	..	1	4	3
Cybele punctata	1	..	1	..	3	1	1	1	1	2	..	2	13	9
——— sexcostata	..	..	1	..	..	..	..	..	..	2	..	..	1	1
——— variolaris	1	..	1	..	..	..	5	..	..	2	3	..	12	5
——— verrucosa	..	..	3	..	3	..	..	..	..	..	..	..	6	2
Dalmannia affinis	..	..	2	..	1	..	..	..	..	..	..	..	3	2
——— caudata	3	..	1	..	10	..	10	1	2	8	8	10	53†	9**
——— longicaudata	2	..	..	..	..	..	6	..	..	..	1	1	10	4
Homalonotus Knightii	4	1	..	..	1	..	1	..	..	..	..	2	9	5
Illænus Barriensis	..	..	..	..	..	..	..	..	..	3	..	1	4	2
——— Bowmanni	..	..	3	..	5	..	..	..	..	..	..	..	8	2
——— Rosenbergii	..	..	..	..	2	..	..	..	..	..	..	..	2	1
Lichas verrucosus	..	..	..	..	..	..	..	..	1	..	..	..	1	1
——— laxatus	..	..	1	..	1	..	..	..	..	..	..	..	2	2
Ogygia Buchii	..	..	..	..	6	1	..	..	..	..	..	..	7	2
——— dilatata	..	..	..	..	..	1	..	..	..	..	..	..	1	1
——— Murchisonæ	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Olenus bisulcatus	..	..	..	..	..	..	..	..	..	..	..	1	1	1
——— humilis	..	..	..	..	..	..	..	..	..	..	..	1	1	1
——— spinulosus	..	..	..	..	..	..	..	..	..	..	..	1	1	1
Phacops Downingiæ	2	1	..	..	4	..	3	..	..	..	4	..	14	5
——— subcaudatus	..	1	..	..	..	..	..	..	..	..	..	..	1	1
——— Stokesii	..	..	..	..	..	1	..	..	..	..	..	1	2	2
Proetus latifrons	..	..	..	..	1	..	1	..	..	..	..	..	2	2
——— Stokesii	..	..	..	..	1	..	..	..	..	2	2	..	5	3
Sphærexochus juvenis	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Trinucleus fimbriatus	..	..	..	..	..	..	..	..	..	..	..	1	1	1
——— granulatus	..	..	..	..	4	..	..	..	..	..	..	..	4	2
——— ornatus	1	..	8	..	9	..	..	..	..	..	..	1	19	4
——— radiatus	..	..	..	..	1	..	..	..	..	..	..	..	1	1
No. of Occurrences in each District	19	3	44	1	80	12	36	5	6	25	28	32	..	..
No. of Species in each District	9	3	16	1	24	9	12	5	3	8	11	17	..	..

Number of Species admitted 45. West 36 24 East.

Number of Occurrences admitted 291 West 169 130 East.

† Maximum number.

The distribution of living Crustacea over the surface of the globe is such, that their structural variety, the number of specific forms, and the number of natural groups increase greatly, and with some regularity, from the Polar Seas toward the Equator. Individuals of a given species may be as numerous round the shores of cold seas as in warmer latitudes, but the number of species is far smaller. It appears that very broad oceans interpose a barrier difficult for the Crustacea to pass, and that thus arise, even in continuous tracts of ocean, districts in which particular races become very prevalent, and within which some species are absolutely confined. Three such districts are marked out by Milne Edwards in European seas; viz., the Scandinavian coasts, the coasts of Britain and France, and the Mediterranean.

In reference to this subject, it is remarkable that in the preceding lists not one species is named which has yet been found in all the twelve districts, though three (*Dalmannia caudata, Calymene Blumenbachii*, and *Cybele punctata*) are known to occur in nine of the districts.

The most abundant of all species is *Dalmannia caudata*, and the next to it the long-famous Dudley trilobite, *Calymene Blumenbachii*. To the latter we annex a single, to the former a double, asterisk.

It is frequently observable, that the species which are found in most districts are also those which are found most abundantly in each: effects due to the same cause, viz., the high rate of distributiveness of those species. It remains to be seen if the same influence can be traced in the depths of strata which they inhabit; in other words, whether their geological duration was proportional to their geographical extension.

In the following Table *Dalmannia caudata*, which has the widest geographical and greatest numerical predominance, is found to occur in the greatest number of strata. In geological duration it is not surpassed by any species.

TABLE IV.—*Geological Distribution of Crustacea in the Eastern Region.*

NAMES OF SPECIES.	STRATA IN DESCENDING ORDER.												No. of Occurrences of each Species.	No. of Strata in which each Species occurs.
	Downton Sandstone.	Upper Ludlow.	Aymestry Rock.	Lower Ludlow.	Wenlock Lime.	Wenlock Shale.	Woolhope Lime.	Caradoc (Upper).	Caradoc (Lower).	Trap Beds.	Black Shale.	Lowest Sandstone.		
Beyrichia tuberculata	..	*	..	..	..	..	..	..	..	..	..	..	7	1
Cytherina	..	*	*	*	..	..	..	..	..	..	..	..	4	3
Acidaspis bispinosus	..	..	..	..	*	..	..	..	..	..	..	..	1	1
——— Brightii	..	..	..	*	*	*	..	‡	..	..	..	..	5	3
Ampyx parvulus	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Asaphus tyrannus	..	..	..	..	*	..	..	‡‡	..	..	..	..	22	1
Calymene Blumenbachii	..	*	..	*	..	..	..	..	..	..	..	..	0	4*
——— tuberculosa	..	*	*	..	*	..	..	..	..	..	..	..	1	1
Cheirurus speciosus	..	..	..	..	*	..	..	..	..	..	..	..	1	1
Cybele punctata	..	*	..	..	..	*	..	*	..	..	..	..	7	3
——— variolaris	..	*	*	..	*	*	..	..	..	..	..	..	10	4
Dalmannia caudata	..	*	*	*	*	*	*	*	..	..	..	..	39†	7**
——— longicaudata	..	..	..	*	..	..	..	..	..	..	..	..	8	2
Homalonotus Knightii	..	*	..	..	*	..	..	..	..	..	..	..	3	2
Illænus Barriensis	..	..	..	..	*	..	*	..	..	..	..	..	4	2
Lichas, sp. not described	..	..	..	..	*	..	..	..	..	..	..	..	1	1
Olenus bisulcatus	..	..	..	..	..	..	..	..	..	..	*	..	1	1
——— humilis	..	..	..	..	..	..	..	..	..	..	*	..	1	1
——— spinulosus	..	..	..	..	..	..	..	..	..	..	*	..	1	1
Phacops Downingiæ	..	..	*	*	*	*	..	..	..	..	..	..	7	4
——— Stokesii	..	..	..	..	..	*	..	..	..	..	..	..	1	1
Proetus latifrons	..	*	..	..	..	..	..	..	..	..	..	..	1	1
——— Stokesii	..	*	*	..	..	*	..	..	..	..	..	..	4	3
Trinucleus fimbriatus	..	..	..	..	..	..	..	..	..	..	*	..	1	1
——— ornatus	..	..	..	..	..	..	..	*	..	..	..	..	1	1
No. of Species in each Stratum	..	10	6	6	11	8	2	4	..	..	4	..	..	..
		In Upper Silurian, 19 species.						In Lower Silurian, 8 species.						

Of the 25 species here noticed in the eastern region, five occur among the nine which have been collected in the course of the Survey near Builth. These are,—

Beyrichia tuberculata.
Cytherina.
Calymene Blumenbachii.
***Cybele punctata.**
Phacops Stokesii.

} Which may be regarded as belonging mostly to the Upper Silurian series, though one (*Cybele punctata*) at least penetrates into the Upper Caradoc sandstone; this is marked with an asterisk.

Of the same 25 species, 13 have been observed in the region of the Towy, which yields in all 24 species. These are,—

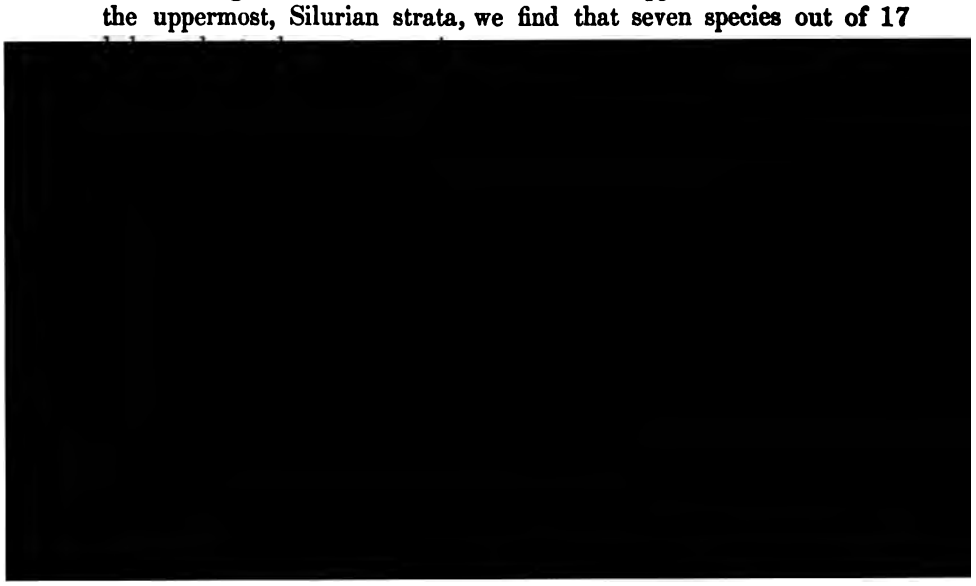
Beyrichia tuberculata.
****Asaphus tyrannus.**
Calymene Blumenbachii.
Acidaspis Brightii.
Cheirurus speciosus.
***Cybele punctata.**
***Dalmannia caudata.**
Homalonotus Knightii.
Phacops Downingiæ.
Proetus latifrons.
——— Stokesii.
****Trinucleus granulatus.**
****——— ornatus.**

} Of these, five have occurred in strata as low as the Caradoc sandstone, in the eastern region. The analogy between the eastern region and the region of Llandilo is numerically considerable, especially in Upper Silurian forms. Three of the species may be regarded as essentially Lower Silurian; these are marked by the double asterisk, and belong to the Llandilo limestone series.

TABLE V.— *Geological Distribution of Crustacea in the Region of the Towy.*

NAMES OF SPECIES.	Upper. STRATA. Lower.			No. of Occurrences of each Species.	No. of Strata in which each Species occurs.
	Tilestone Bands.	Myddelton Group.	Llandilo Limestone Series.		
Beyrichia complicata	..	..	*	1	1
——— tuberculata	*	*	..	2	2
Acidaspis Brightii	..	*	..	3	1
Agnostus pisiformis	..	..	*	1	1
Asaphus tyrannus	..	..	*	15	1
Calymene Blumenbachii	*	*	..	2	2
——— brevicapitata	..	..	*	2	1
——— duplicata	..	..	*	1	1
Cheirurus speciosus	..	*	..	1	1
Cybele punctata	..	*	..	3	1
——— verrucosa	..	..	*	3	1
Dalmannia affinis	..	..	*	1	1
——— caudata	..	*	*	10	2
Homalonotus Knightii	..	*	..	1	1
Illænus Bowmannii	..	*	*	5	1
——— Rosenbergii	..	*	*	2	1
Lichas laxatus	..	*	..	1	1
Ogygia Buchii	..	..	*	6	1
Phacops Downingiæ	..	*	..	4	1
Proetus latifrons	..	*	..	1	1
——— Stokesii	..	*	..	1	1
Trinucleus granulatus	..	..	*	4	1
——— ornatus	..	..	*	9	1
——— radiatus	..	..	*	1	1
No. of species in each group	2	13	14	..	..

Passing farther to the west, we find in the Haverfordwest and Caermarthen region, which contains none of the upper, at least none of the uppermost, Silurian strata, we find that seven species out of 17



Calymene Blumenbachii. *Cybele punctata. ——— variolaris. *Dalmannia caudata. ——————— longicaudata. Homalonotus Knightii. Phacops Downingiæ. **Trinucleus ornatus.	Of these, three have occurred in the lower strata of the eastern region; and one, the same as already signalized, appears peculiar to the Lower Silurian strata.

TABLE VI.—*Geological Distribution of Crustacea in the Cliffs of Marloes Bay, between West Dale Point and the Trap.*

NAMES OF SPECIES.	STRATA IN DESCENDING ORDER.		
	Gray Sandstone.	Shales, Coral, &c.	Conglomerates.
Calymene Blumenbachii . .	*	*	..
Cybele punctata	..	*	..
——— variolaris	..	..	..
Dalmannia caudata	*	..	..
——————— longicaudata . .	*	..	..
Homalonotus Knightii . . .	*	..	..
Phacops Downingiæ	*	..	..

In shales below the trap (at Musclewick Bay) *Trinucleus ornatus*, *Asaphus tyrannus*, and *Ogygia Buchii* occur, but in the section of Marloes Bay and Wooltack Bay not a single trilobite occurs which can justify a reference of any part of the series to the Lower Silurian rocks; for though *Cybele punctata* does occur in Caradoc sandstone at Malvern, it is found in Wenlock and even Ludlow rocks elsewhere. Compared with the strata near Narberth, the section of Marloes Bay would appear mostly to come above the conglomerate of Robeston Wathen, which would thus stand on the boundary line between the Upper and Lower Silurians. This conglomerate is much above the Llandilo limestones.

The degree of completeness in which trilobites occur offers a curious matter of inquiry. The easy decay of the slender ligamental connexions between the head, thoracic, and caudal plates, allows us to witness the frequently separated state of those parts without surprise. But it is very rare to find in the limestone of the Malvern district, amid hundreds of separated heads and tails, even one entire *Dalmannia caudata*. I do not remember to have seen one perfect trilobite in the Marloes region. In the shales about Llandilo, on the contrary, *Asaphus tyrannus*, *Ogygia Buchii*, *Calymene brevicapitata*, are often found entire. The case is perhaps analogous to what occurs with regard to the *Palæonisci*, *Tetragonolepides*, and other fossil fishes, which in some localities are in scattered fragments, but in certain repositories (marl

slate of Durham, lias balls of Barrow on Soar) are found in great numbers quite complete. It is often in deposits which, by peculiarity of aggregation, indicate quick, gentle, and continuous deposition, that we find trilobites, fishes, and enaliosaurians complete: perhaps generally the degree of separation of their parts may be proportioned to the length of time, and the strength of watery currents to which they were subject; but in the case of the *Dalmanniæ*, one is inclined to suspect, from the rarity of thoracic rings among so many heads and tails, that this species was the favourite food of some coeval zoophagous race.

CEPHALOPODA.

The families of recent and Silurian Cephalopoda may be thus compared:—

Recent.	Orders.	Silurian.
Several . .	OCTOPODA . . .	None.
	DECAPODA.	
Several . .	Teuthidæ . . .	None.
Several . .	Sepiadæ	None.
Few . . .	Spirulidæ . . .	None.
Few . . .	Nautilidæ . . .	Several.
None . .	Lituitidæ . . .	Several.
None . .	Orthoceratidæ . .	Many.

The Cephalopoda of the Lower Palæozoic strata may be thus classed:—

Family—ORTHOCERATIDÆ.

Shell straight or arcuate; septa uniformly concave toward the aperture, often slightly oblique to the axis; siphon central or subdorsal; aperture sinuated (contracted, or even closed across the middle).

The Orthoceratidæ may hereafter admit of good generic division

Orthoceratidæ, 1*st Division.*

ORTHOCERAS APPROXIMATUM.

REF.—Murchison, Sil. Syst., t. 21, f. 22.

Malvern District . . Cowley Park. Obelisk.

ORTHOCERAS BISIPHONATUM.

REF.—Murchison, t. 21, f. 23.

Llandilo District . . Gorllwyn fach (Murch.).

ORTHOCERAS BRIGHTII.

REF.—Murchison, Sil. Syst., t. 12, f. 21.

[Mr. Salter has ascertained the *O. Mocktreense*, Sil. Syst, t. 6, f. 11, to be the same species with *O. Brightii*, from an examination of fine specimens in the collection of the Rev. T. Lewis, Bridstow, Ross.]

The specimens which have yet been seen show no septa, though the central siphon is very complete, enveloped by calcareous spar.

Malvern District . . Ledbury. Hales End, Matton Lodge.

ORTHOCERAS CONICUM.

REF.—Murchison, Sil. Syst., t. 21, f. 21.

Malvern District . . Cowley Park. Obelisk.
Tortworth District . . Pyrton Passage.
Usk District . . . Llanfrechfa.

ORTHOCERAS ECCENTRICUM.

REF —Murchison, Sil. Syst., t. 13, f. 16.

Woolhope District . . Bodenham, A.L. Shucknall, A L.

ORTHOCERAS MARLOENSE, Phillips.

REF.—Palæontological Appendix.

Marloes District . . Marloes Bay, E 9.

ORTHOCERAS IMBRICATUM.

REF.—Murchison, Sil. Syst., t. 9, f. 2.

Abberley District . . Barrell Hill.
Woolhope District . . N.E. of Pilliard's Barn.
Usk District . . . Llanbadoc, U.L.
Llandilo District . . Storm Hill Lodge.
Marloes District . . Marloes Bay?

ORTHOCERAS LUDENSE.

REF.—Murchison, Sil. Syst., t. 9, f. 1 a.

Malvern District . . Mathon Lodge.
Builth District . . . Llanfaredd.

ORTHOCERAS NUMMULARIUS.

REF.—Murchison, Sil. Syst., t. 13, f. 24.

Tortworth District . . Whitfield Quarry (Murchison).

ORTHOCERAS POMEROENSE?

REF.—Portlock, Geol. Rep., f. 370, t. 26, f. 4, 5.

Llandilo District . . Pen y goylan. Bird's Hill Quarry.

ORTHOCERAS SEMIPARTITUM.

REF.—Murchison, Sil. Syst., t. 3, f. 9 a.

Builth District . . . Pwll ddu?
Llandilo District . . Storm Hill Lodge. South of Trichrug. Horeb Chapel.

ORTHOCERAS TRACHEALE.

REF.—Murchison, Sil. Syst., t. 3, f. 9 b.

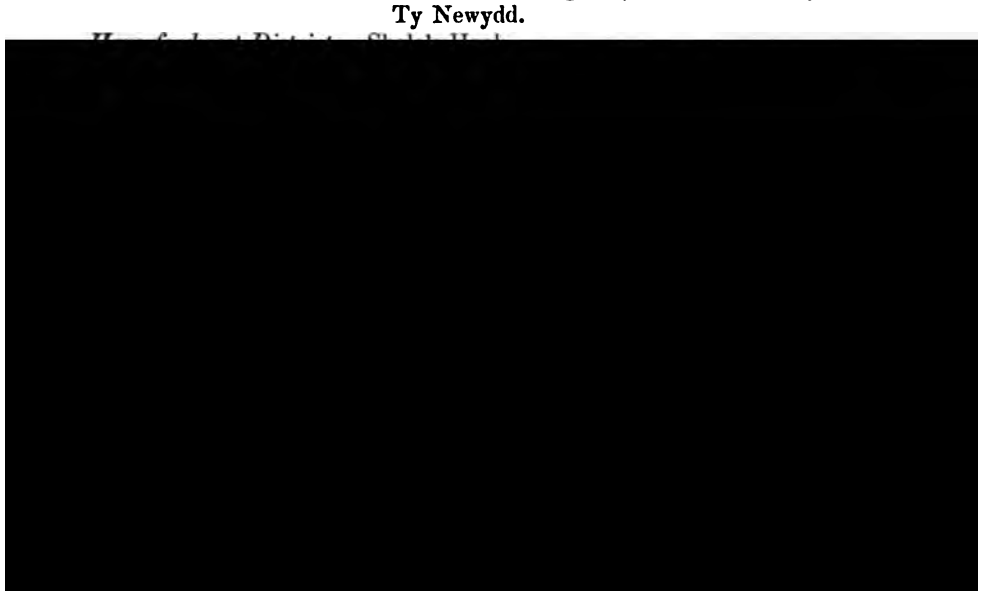
Usk District . . . Llanfrechfa.
Llandilo District . . Horeb Chapel. Storm Hill Lodge.

Orthoceratidæ, 2nd Division.

ORTHOCERAS ANNULATUM.

REF.—Murchison, Sil. Syst., t. 9. f. 5 (*O. undulatus*, Hisinger).

Malvern District . . Under Worcester Beacon, W.S. Hereford Beacon. Stump's Wood. Awkbridge Farm. East of Ledbury.
Abberley District . . Martley Road. East of Ridge Hill Farm.
Woolhope District . . Bodenham, A.L. Little Hope.
May Hill District . . Rock Farm.
Llandilo District . . Mandinam. Goleugoed (Murch.) Gorllwyn fach. Ty Newydd.



ORTHOCERAS TEXTILE, Phillips.

Freshwater District . Freshwater East.

Orthoceratidæ, 3rd Division.

ORTHOCERAS IBEX.

REF.—Murchison, Sil. Syst., t. 5, f. 30.

Malvern District . . Hale's End, U.L.
Abberley District . . Walsgrove Hill. Hole Farm, U.L. Ridge Hill.
Woolhope District . . Stoke Edith. N.E. of Pilliard's Barn. Bodenham, A.L. Shucknall.
May Hill District . . S.W. of Hobbs.
Usk District . . . Llanfrechfa. Usk Castle. Llangibby.
Builth District . . . Blaenau. Cwm Craig ddu, U.L.
Llandilo District . . Dafaddfa Uchaf South.

ORTHOCERAS PERELEGANS, Salter.

REF.—Palæontological Appendix.

Usk District . . . Usk Castle.

Orthoceratidæ, 4th Division.

ORTHOCERAS ANGULATUM.

REF.—*O. angulatus*, His. Leth. Succ. *O. virgatum*, Murchison, Sil. Syst., t. 9, f. 4.

Malvern District . . Mathon Lodge. Hale's End, U.L.
Abberley District . . Abberley, A.L. (Murchison). Ridge Hill.
Woolhope District . . N.E. of Pilliard's Barn. Bodenham, A.L. Shucknall Hill, A.L. Dormington Wood.
Usk District . . . Near Radyr. Llanbadoc, A.L. Trostra Farm. Craig y garcyd. Llangibby, A.L.
Llandilo District . . Golden Grove, 3, 4. Ty Newydd.
Marloes District . . Marloes Mill Brook.

ORTHOCERAS CANALICULATUM.

REF.—Murchison, Sil. Syst., t. 13, f. 2c.

Malvern District . . Mathon Lodge.

ORTHOCERAS FIMBRIATUM.

REF.—Murchison, Sil. Syst., t. 13, f. 20.

Malvern District . . Brock Hill, L.L.
Woolhope District . . Dormington Wood.
Llandilo District . . Cwm gerwyn, N. of Llandilo.

Lituitidæ.

Lituites giganteus.

Ref.—Murchison, Sil. Syst., t. 11, f. 4.

Malvern District . . Under Worcester Beacon, W.S. Upper Mitchell.
Abberley District . . Fetlock's Farm.
Usk District . . . Craig y garcyd.
Llandilo District . . Gilfach.

Lituites Biddulphii.

Ref.—Murchison, Sil. Syst., t. 11, f. 8.

Malvern District . . Ledbury (Murchison).

Lituites ibex.

Ref.—Murchison, Sil. Syst., t. 11, f. 6.

Malvern District . . Pound. Overley. Frith Farm. Mathon Lodge.
Woolhope District . . Bodenham, A.L. Shucknall, A.L. Wonder, A.L.
May Hill District . . West of Rock Farm.
Usk District . . . Usk Castle. Llangibby, A.L. Cefn Ila, L.L.
Llandilo District . . North of Trichrug.

Lituites cornu-arietis.

Ref.—Murchison, Sil. Syst., t. 20, f. 20, and t. 22, f. 18.

Llandilo District . . Cefn y garreg.

Lituites undosus.

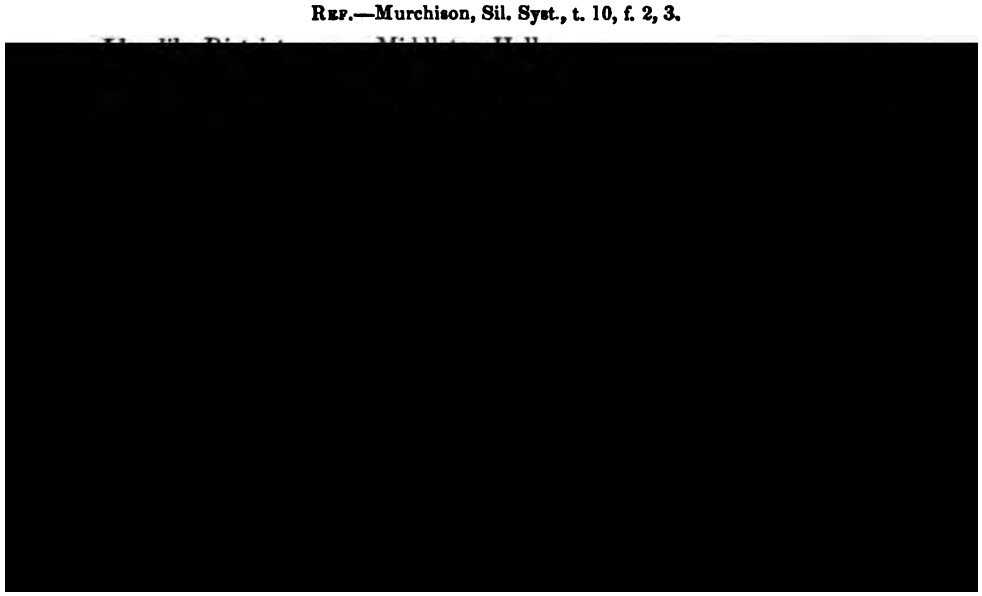
Ref.—*Naut. undosus.* Murchison, Sil. Syst., t. 22, f. 17. Palæontol. Appendix.

Llandilo District . . Blaen y cwm (Murch.)

Nautilidæ.

Phragmoceras nautileum.

Ref.—Murchison, Sil. Syst., t. 10, f. 2, 3.



Woolhope District . . Dormington Wood.
Llandilo District . . Gorllwyn fach. Goleugoed.

Specimens of undetermined species of Phragmoceras occur at Wallgrove in the Abberley hills, and at Shucknall in the Woolhope district, both in Upper Ludlow beds.

TABLE VII.—*Geographical Distribution of Cephalopoda.*

NAMES OF SPECIES.	Western Districts.						Eastern Districts.						No. of Occurrences of each Species.	No. of Districts in which each Species occurs.
	Marloes.	Freshwater.	Haverfordwest.	Caermarthen.	Llandilo.	Builth.	Usk.	Tortworth.	May Hill.	Woolhope.	Abberley.	Malvern.		
Orthoceras approximatum	..	..	..	..	..	..	..	..	..	..	..	2	2	1
——— bisiphonatum	..	..	..	..	1	..	..	..	..	..	..	..	1	1
——— Brightii	..	..	..	..	..	..	..	..	..	..	..	3	3	1
——— conicum	..	..	..	..	..	..	1	1	..	..	..	2	4	3
——— eccentricum	..	..	..	..	..	..	..	..	..	2	..	..	2	1
——— Marloensis	1	..	..	..	..	..	..	..	..	..	..	..	1	1
——— imbricatum	?	..	..	..	1	..	1	..	..	1	1	..	4	4
——— Ludense	..	..	..	..	..	..	1	..	..	..	..	1	2	2
——— nummularius	..	..	..	..	..	..	..	1	..	..	..	..	1	1
——— Pomeroense ?	..	..	..	..	2	..	..	..	..	..	..	..	2	1
——— semipartitum	..	..	..	..	3	1	..	..	..	..	..	..	4	2
——— tracheale	..	..	..	..	2	..	1	..	..	..	..	..	3	2
Orthoceras annulatum	..	..	1	..	4	..	..	..	1	1	3	5	15	6
——— bullatum	1	..	..	..	6	3	2	1	..	3	2	3	21	8*
——— textile	..	1	..	..	..	..	..	..	..	..	..	..	1	1
——— ibex	..	..	..	..	1	2	3	..	1	4	2	1	14	7
——— perelegans	..	..	..	..	..	..	1	..	..	..	..	..	1	1
——— angulatum	1	..	..	..	2	..	5	..	..	4	1	2	15	6
——— canaliculatum	..	..	..	..	..	..	..	..	..	..	..	1	1	1
——— fimbriatum	..	..	..	..	1	..	..	..	..	1	..	1	3	3
Lituites giganteus	..	..	..	..	1	..	1	..	..	..	1	2	5	4
——— Biddulphii	..	..	..	..	..	..	..	..	..	..	..	1	1	1
——— ibex	..	..	..	..	1	..	3	..	1	3	..	4	12	5
——— cornu-arietis	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Phragmoceras nautileum	..	1	1	..	1	..	..	..	..	..	..	..	3	3
——— compressum	..	..	..	..	..	1	..	..	..	..	..	..	1	1
——— pyriforme	..	..	..	..	2	..	..	..	..	1	..	1	4	3
Lituites undosus	..	..	..	..	1	..	..	..	..	..	..	..	1	1
No. of Occurrences in each District	3	2	2	..	30	7	19	3	3	20	10	29	..	..
No. of Species in each District	3	2	2	..	16	4	10	3	3	9	6	14	..	..

Number of Species admitted 28. West 19 19 East.

Number of Occurrences admitted 128. West 44 84 East.

TABLE VIII.—*Geological Distribution of Cephalopoda in the Eastern Region.*

NAMES OF SPECIES.	STRATA IN DESCENDING ORDER.												No. of Occurrences of each Species.	No. of Strata in which each Species occurs.
	Downton Sandstone.	Upper Ludlow.	Aymestry Rock.	Lower Ludlow.	Wenlock Limestone.	Wenlock Shale.	Woolhope Limestone.	Caradoc Sandstone.	Caradoc Conglomerate.	Trap.	Black Shale.	Lowest Sandstone.		
Orthoceras approximatum	..	..	..	..	..	..	..	..	*	..	..	..	2	1
——— Brightii	..	*	..	..	*	..	..	..	..	..	..	..	3	2
——— conicum	..	*	..	..	..	..	..	..	*	..	..	..	4	2
——— eccentricum	..	..	*	..	..	..	..	..	..	..	..	..	2	1
——— imbricatum	..	*	..	..	..	..	..	..	..	..	..	..	3	1
——— Ludense	..	*	..	..	..	..	..	..	..	..	..	..	1	1
——— nummularius	..	..	..	..	..	..	..	..	..	..	..	..	1	1
——— tracheale	..	*	..	..	..	..	..	*	..	..	..	..	1	1
——— annulatum	..	..	*	*	*	..	*	..	..	..	..	..	9	4
——— bullatum	..	*	..	..	..	..	..	..	..	..	..	..	9	1
——— ibex	.	*	*	..	..	..	..	..	..	..	..	..	11	2
——— perelegans	..	*	..	..	..	..	..	..	..	..	..	..	1	1
——— angulatum	..	*	*	..	*	*	..	..	..	..	..	..	12	4
——— canaliculatum	..	*	..	..	..	..	..	..	..	..	..	..	1	1
——— fimbriatum	..	..	..	*	*	..	..	..	..	..	..	..	2	2
Lituites giganteus	..	*	..	..	†	*	..	..	..	..	..	..	4	3
——— Biddulphii	..	..	..	..	1	..	..	..	..	..	..	..	1	1
——— ibex	..	*	*	*	..	..	..	..	..	..	..	..	12	3
Phragmoceras pyriforme	..	..	..	..	2	..	..	..	..	..	..	..	2	1
Number of Occurrences	..	42	12	3	14	3	2	1	4	..	..	..	..	..
No. of Species in each Stratum	..	12	5	3	7	2	1	1	2	..	..	..	..	..

Number of species admitted, 19: of which, in Lower Silurian, 3; in Upper Silurian, 17. Common to both, one species, viz., *O. conicum*. Dividing the Upper Silurian strata into the Ludlow and Wenlock groups, we have in Wenlock 7 species, in Ludlow 14; and, finally, while in Upper Ludlow are 12 species, 5 occur in Aymestry lime, and 3 in Lower Ludlow.

It may perhaps be inferred as a general result, that the abundance

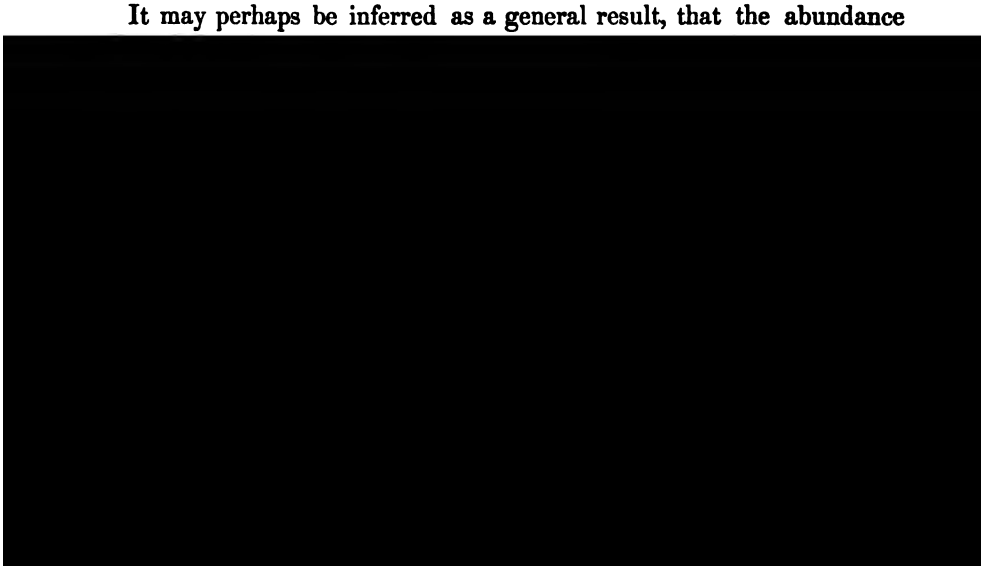


TABLE IX.—*Geological Distribution of Cephalopoda in the Llandilo Region.*

Names of Species.	Strata in Descending Order.			No. of Occurrences of each Species.	No. of Strata in which each Species occurs.
	Tilestone.	Myddleton Group.	Llandilo Group.		
Orthoceras bisiphonatum . .	..	*	..	1	1
——— imbricatum . . .	*	..	..	1	1
——— Pomeroense . . .	..	..	*	1	1
——— semipartitum . .	*	..	..	3	1
——— tracheale . . .	*	..	..	2	1
——— annulatum . . .	..	*	..	4	1
——— bullatum. . . .	*	*	..	6	2
——— ibex	*	..	..	1	1
——— angulatum . . .	..	*	..	3	2
——— fimbriatum . . .	..	*	..	1	1
Lituites giganteus	..	*	..	1	1
——— ibex	..	*	..	1	1
——— cornu-arietis . . .	..	*	..	1	1
Phragmoceras nautileum . .	..	*	..	1	1
——— pyriforme . .	..	*	..	2	1
Lituites undosus	..	..	*	1	1
No. of Species in each group of Strata	5	10	2	..	..

In this series the comparative rarity of Cephalopoda in the lowest group—that of the Llandilo limestones—is remarkable; a character which it shares with the lower Silurians of the eastern region, and of the districts farther west.

HETEROPODA.

This group is joined to Gasteropoda by some writers under the title of Nucleobranchiata: by others the Bellerophontes have been regarded as shells of monothalamic Cephalopods, like Argonauta.

BELLEROPHON ACUTUS.

REF.—Murchison, Sil. Syst., t. 19, f. 14.

Malvern District . . Obelisk. Gunwick Mill. Cowley Park. West of Worcester Beacon, U.C.

BELLEROPHON AYMESTRIENSIS.

REF.—Murchison, Sil. Syst., t. 6, f. 12.

[Mr. Salter has determined this to be the same species with *B. dilatatus*, by specimens in the Rev. J. Lewis's collection.]

BELLEROPHON BILOBATUS.

REF.—Murchison, Sil. Syst., t. 19, f. 13.

Tortworth District . .	Horse Shoe Farm (Murch.)
Builth District . . .	Carneddau.
Marloes District . .	Wooltack.

BELLEROPHON CARINATUS.

REF.—Murchison, Sil. Syst., t. 3, f. 4.

Usk District . . .	Llanfrechfa.
Llandilo District . .	Horeb Chapel (Murch.) Swansea Road, 2. Dafaddfa Uchaf.
Marloes District . .	Marloes Bay, E.

BELLEROPHON DILATATUS.

REF.—Murchison, Sil. Syst., t. 12, f. 23, 24.

Malvern District . .	Near Dog Hill, A.L.
Woolhope District . .	Dormington Wood. Bodenham, A.L. Welch Court. Lindels.
Usk District . . .	Llanbadoc, A.L.
Tortworth District . .	Pyrton Passage (Weaver).

BELLEROPHON EXPANSUS.

REF.—Murchison, Sil. Syst., t. 5, f. 32.

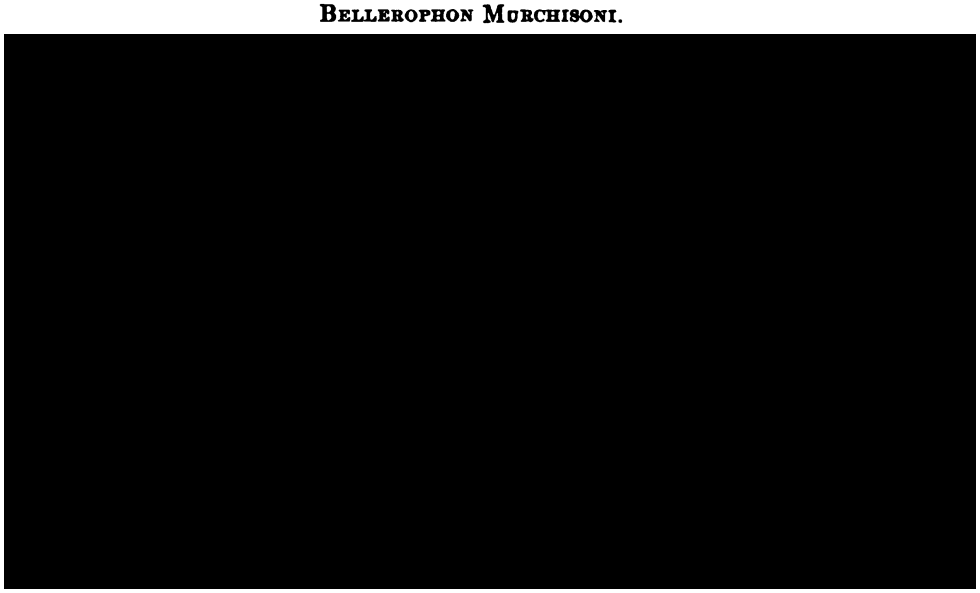
Malvern District . .	Mathon Lodge. Frith Farm. Near Hall's Court.
Abberley District . .	Barrell Hill.
Builth District . . .	Pwll ddu. Cwm Craig ddu, U.L.
Llandilo District . .	Storm Hill Lodge. Pont-ar-y Llechau.
Freshwater District .	Freshwater East.

BELLEROPHON GLOBATUS.

REF.—Murchison, Sil. Syst.,

Malvern District . .	Hale's End, U.L.
Llandilo District . .	Dafaddfa Uchaf.

BELLEROPHON MURCHISONI.



Woolhope District . . Bodenham, A.L. Shucknall, A.L.
Tortworth District . . Charfield Green.
Builth District . . . Pwll ddu.
Llandilo District . . Dafaddfa Uchaf. South of Trichrug. Storm Hill Lodge. Golden Grove, T.S. Pont-ar-y Llechau.
Freshwater District . Freshwater East.
Marloes District . . Marloes Bay, C. E.

BELLEROPHON WENLOCKENSIS.

Malvern District . . Eastnor. Croft, W.S. Ledbury.
Abberley District . . E. of Hill End.
Woolhope District . . Dormington Wood. Lindel's Quarry.
Marloes District . . Marloes Bay, E.

PTEROPODA.

The few Palæozoic fossils which have yet been positively referred to this small group of Mollusca, are included in the genera *Conularia*, *Creseis*, and *Theca*. The affinity of *Conularia* to the tetragonal recent pteropods is obvious; *Creseis* was added to the list by Professor E. Forbes. Perhaps *Cyrtolites* (*Ecculiomphalus* of Portlock, *Cyrtoceras* of Murchison) may belong to the group. The specimens generally belong to Upper Silurian rocks.

CONULARIA SOWERBII.

REF.—Murchison, Sil. Syst., t. 12, f. 21, 22.

Malvern District . . Mathon Lodge. Awkbridge Farm.
Abberley District . . Abberley. Hill End, W.L.
Llandilo District . . Middleton. Cefn y garrig.
Haverfordwest District . Priory Mill.
Marloes District . . Slate Mill.

THECA FORBESII.

REF.—Palæontological Appendix.

Abberley District . . Barrell Hill.
Woolhope District . . Bodenham, U.L.
Usk District . . . Llanfrechfa. Cefn Ila, L.L.
Builth District . . . Pwll ddu. Cwm Craig ddu, U.L.
Llandilo District . . Bird's Hill Quarry. Dafaddfa Uchaf.

THECA? ANCEPS, Salter.

REF.—Palæontological Appendix.

Malvern District . . South of Eastnor Castle.

GASTEROPODA.

The *orders* of Silurian Gasteropoda which have yet been discovered appear in the following table :—

Living.	Orders.	Silurian.
Many . .	Nudibranchiata . .	None.
Several . .	Inferobranchiata .	None.
Many . .	Tectibranchiata . .	None.
Many . .	Pulmonifera . . .	None.
Numerous .	*Pectinibranchiata* .	Several.
Many . .	Scutibranchiata . .	None.
Many . .	Cyclobranchiata . .	Very few.
Few . . .	Cirrhobranchiata .	None.

The two great groups of Pectinibranchiata offer the following comparison :—

Living.	Sub-Orders.	Silurian.
Numerous .	Siphonostomata . .	None ?
Numerous .	*Holostomata* . . .	Several.

Thus it appears that one section of one family of Gasteropoda includes the greater part of the species which have yet been certainly recognized among the Silurian mollusca.

Two of the most numerous generic groups of Gasteropoda in the Silurian strata, viz., *Pleurotomaria* and *Euomphalus*, appear allied to two remarkable living genera of mollusca, in which only very few species occur, viz., *Ianthina* and *Vermetus*. Other genera, as *Schizos-*

EUOMPHALUS ALATUS.

REF.—Murchison, Sil. Syst., t. 13, f. 28.

Malvern District . .	Chance's Pitch. Upper Mitchell.
Woolhope District . .	Bodenham.
Usk District . . .	Craig y garcyd.
Builth District . . .	Erw gilfach.

EUOMPHALUS ALATUS, var. SUBUNDULATUS.

REF.—Palæontological Appendix.

Abberley District . .	Bason Court Farm. Ridge Hill.
Woolhope District . .	S. of Putley.

EUOMPHALUS CARINATUS.

REF.—Murchison, Sil. Syst., t. 6, f. 10.

Malvern District . .	Overley. Halesend, U.L.

EUOMPHALUS CORNDENSIS.

REF.—Murchison, Sil. Syst., t. 22, f. 16.

Malvern District . .	The Wych.

EUOMPHALUS DISCORS.

REF.—Murchison, Sil. Syst., t. 12, f. 18.

Malvern District . .	Eastnor.
Woolhope District . .	Dormington Wood. Bodenham, A.L.
Llandilo District . .	Golden Grove, 4 (young).

EUOMPHALUS FUNATUS.

REF.—Murchison, Sil. Syst., t. 12, f. 20.

Malvern District . .	Chance's Pitch. Brockhill, U.L., L.L. Upper Mitchell. W. of Rilbury. Dunbridge Wood, Ledbury.
Woolhope District . .	Prior's Court. Backbury Hills. Shucknall Hill, A.L. Dormington Wood. Lindels. Bodenham Quarry, A.L. E. of Canwood.
May Hill District . .	Rock.
Tortworth District . .	Falfield.
Usk District . . .	Usk. Llanbadoc, A.L. Llangibby, A.L.
Builth District . . .	Aberedw, A.L.
Llandilo District . .	Middleton Hall. Swansea Road, 6. Ty newydd Llangwm.

EUOMPHALUS QUALTERIATUS.

REF.—Murchison, Geol. Russ., Pl. 23, f. 1, 2.

Llandilo District . .	Bird's Hill Quarry.

EUOMPHALUS PRÆNUNTIUS, Phillips.

REF.—Palæontological Appendix.

Malvern District . .	Gunwick Mill. Alfrick Pound. The Wych.
May Hill District . .	Huntley Hill.

EUOMPHALUS SCULPTUS.

REF.—Murchison, Sil. Syst., t. 12, f. 17.

Malvern District . .	Ledbury.
Woolhope District . .	Bodenham, A.L. Backbury Camp. Lindels.
Usk District . . .	Llanbadoc, A.L. Trostra, W.L.
Builth District . . .	Aberedw, U.L.
Llandilo District . .	Myddleton Hall.
Marloes District . .	Marloes Bay.
Freshwater District .	Freshwater East.
Cardigan District . .	Abereiddy Bay.

EUOMPHALUS TENUISTRIATUS.

REF.—Murchison, Sil. Syst., t. 22, f. 14.

Llandilo District . .	Middleton Hall (Murch.)

LITTORINA STRIATELLA.

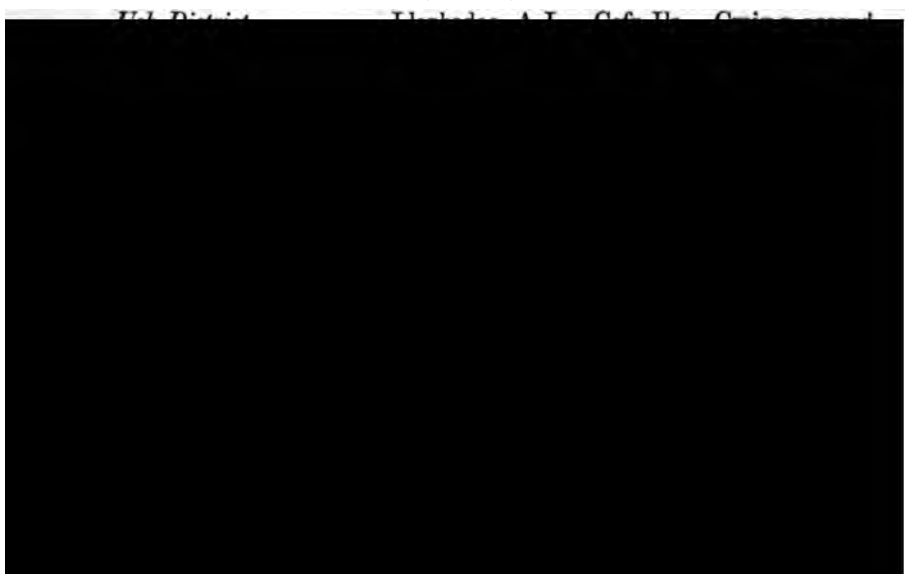
REF.—Murchison, Sil. Syst., t. 19, f. 12.

Malvern District . .	Obelisk.
Tortworth District . .	Long's Quarry.
Llandilo District . .	Golden Grove.
Marloes District . .	Marloes Bay.

LOXONEMA SINUOSA.

REF.—*Terebra? sinuosa*, Murchison, Sil. Syst., t. 8, f. 15.

Malvern District . .	Under Worcester Beacon, U.C., and under Here ford Beacon.



Woolhope District . . Welsh Court. Bodenham, A.L. Shucknall, A.L.
Usk District . . . Llangibby, A.L.
Llandilo District . . Golden Grove, 3.
Marloes District . . Marloes Bay.

MURCHISONIA POLYGLYPHA, Phillips.

REF.—Palæontological Appendix.

Malvern District . . Gunwick Mill.

NATICA PARVA.

REF.—Murchison, Sil. Syst., t. 5, f. 24.

Woolhope District . . Fownhope (Murch.). Pilliard's Barn.
Llandilo District . . Dafaddfa Uchaf (*s.*)

NATICA ———.

REF.—*N. glaucinoides?* Murchison, Sil. Syst., t. 3, f. 14.

Woolhope District . . Stoke Edith.
Builth District . . . Pwll ddu.

NERITA PROTOTYPA, Phillips.

REF.—*N. spirata*, Murchison, Sil. Syst., t. 12, f. 15. This name was already appropriated to another species. Palæontological Appendix.

Malvern District . . Ledbury.
Tortworth District . . Horseshoe Farm.

NERITA HALIOTIS.

REF.—Murchison, Sil. Syst., t.12, f. 15.

Malvern District . . Upper Storridge, WP.L. Eastnor. Clincher's Mill. E. of Ledbury.
Woolhope District . . Checkley Common. Pilliard's Barn. E. of Canwood. Dormington Wood. Bodenham.
May Hill District . . South of Rock.
Usk District . . . Cilfigan. Dowlas. Llangibby, A.L.
Llandilo District . . Swansea Road, 6, 4. Ty newydd. Myddelton Hall.
Marloes District . . Marloes Bay. Freshwater East. St. Ishmael's.

PATELLA? IMPLICATA.

REF.—Murchison, Sil. Syst., t. 12, f. 14 a.

Abberley District . . Abberley (Murch.).
May Hill District . . South of Rock.
Usk District . . . Craig y garcyd.

PILEOPSIS VETUSTATIS.

REF.—Murchison, Sil. Syst., p. 625.

Marloes District . . Hooton.

PLEUROTOMARIA ANGULATA.

REF.—Murchison, Sil. Syst., t. 21, f. 20.

Tortworth District . . Long's Quarry.
Llandilo District . . Mandinam.

PLEUROTOMARIA BALTEATA, Phillips.

REF.—Palæontological Appendix.

May Hill District . . Rock Farm.
Llandilo District . . Golden Grove, 4.

PLEUROTOMARIA FISSICARINA, Phillips.

REF.—Palæontological Appendix.

Malvern District . . The Wych.

PLEUROTOMARIA LLOYDII.

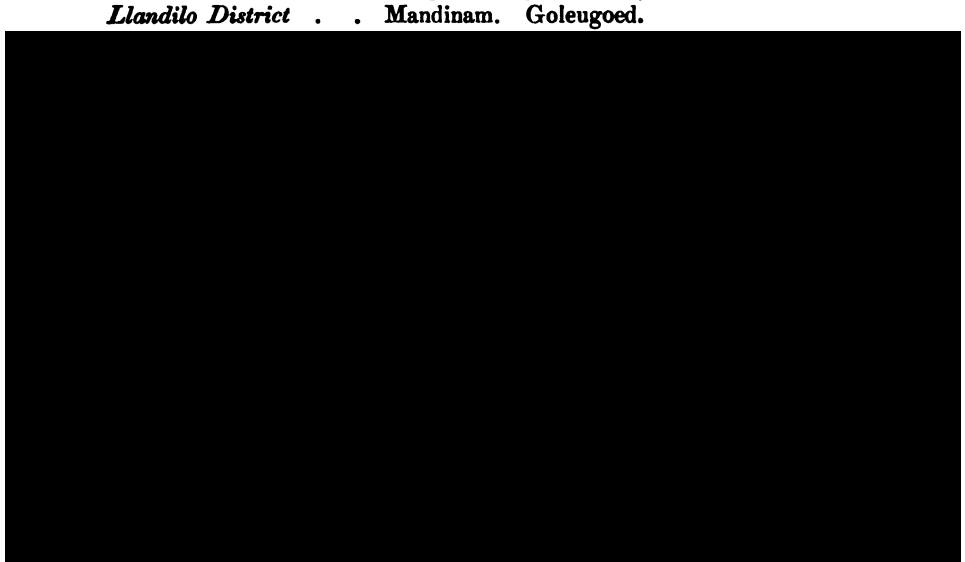
REF.—Murchison, Sil. Syst., t. 8, f. 14.

Malvern District . . Chance's Pitch. Coomb, A.L. W. of Rilbury Camp.
Woolhope District . . Bodenham Quarry, A.L. Perton. Shucknall Hill, A.L.
May Hill District . . S. W. of Hobbs. W. of Rock Farm.
Usk District . . . Usk. Llanbadoc, A.L. Llangibby, A.L.
Freshwater District . Freshwater, East.
Marloes District . . Marloes Bay.

PLEUROTOMARIA PRYCEÆ.

REF.—Murchison, Sil. Syst., t. 21, f. 19.

Malvern District . . Obelisk.
Tortworth District . . Long's Quarry (Weaver).
Llandilo District . . Mandinam. Goleugoed.



TROCHUS LENTICULARIS.

REF.—Murchison, Sil. Syst., t. 19, f. 11.

Malvern District . . Old Storridge. Gunwick Mill. Alfrick Pound.

TURBO CARINATUS.

REF.—Murchison, Sil. Syst., t. 5, f. 28.

Malvern District . . Mathon Lodge.

TURBO CIRRHOSUS.

REF.—Murchison, Sil. Syst., t. 13, f. 22.

Usk District . . . Lancayo.

TURBO WILLIAMSII.

REF.—Murchison, Sil. Syst., t. 3, f. 6.

Llandilo District . . Dafaddfa Uchaf, N. N. of Trichrug. Stormhill Lodge. S. of Carreg Llwyd.

Marloes District . . Marloes Bay H.?

TURBO CORALLII.

REF.—Murchison, Sil. Syst., t. 5, f. 27.

Malvern District . . Coomb Pound, U.L.

Abberley District . . Ankerdine Hill, U.L.

Woolhope District . . Hazle. Stoke Edith. Pilliard's Barn. Welsh Court. Bodenham, U.L.

May Hill District . . W. of Rock Farm.

Usk District . . . Usk Castle. Llanfrechfa. Llanbadoc, A.L.

Builth District . . Henllwyn Hill.

Llandilo District . . Dafaddfa Uchaf, S. Stormhill Lodge. Pont ar y Llechau.

Marloes District . . Freshwater, East.

TURRITELLA CANCELLATA.

REF.—Murchison, Sil. Syst., t. 20, f. 18.

Malvern District . . Obelisk. Cowley Park.

Tortworth District . . Long's Quarry.

Llandilo District . . Mandinam.

TURRITELLA CONICA.

REF.—Murchison, Sil. Syst., t. 3, f. 7 b and 8.

Builth District . . . Pwll ddu.

Llandilo District . . Stormhill Lodge.

TURRITELLA GREGARIA.

REF.—Murchison, Sil. Syst., t. 3, f. 1.

Usk District . . . Usk Castle.

Builth District . . . Pwll ddu.

Llandilo District . . Pont ar y Llechau.
Marloes District . . Marloes Bay.

Turritella obsoleta.

Ref.—Murchison, Sil. Syst., t. 3, f. 7 a and 12 f, g.

Malvern District . . Halesend, U.L.
Usk District . . . Llanbadoc, U.L. Usk Castle.
Llandilo District . . Swansea Road, 2. Stormhill Lodge. Dafaddfa Uchaf, S. and N. Pont ar y Llechau.

Table X.—*Geographical Distribution of Gasteropoda.*

Names of Species.	Western Districts.						Eastern Districts.						No. of Occurrences of each Species.	No. of Districts in which each Species occurs
	Marloes.	Freshwater.	Haverfordwest.	Caermarthen.	Llandilo.	Builth.	Usk.	Tortworth.	May Hill.	Woolhope.	Abberley.	Malvern.		
Cyrtolites lævis	1	.	.	.	.	.	2	.	.	.	1	1	5	4
Euomphalus alatus	.	.	.	.	.	1	1	.	.	1	2	2	7	5
——— carinatus	.	.	.	.	.	.	.	.	.	.	.	2	2	1
——— Corndensis	.	.	.	.	.	.	.	.	.	.	.	1	1	1
——— discors	.	.	.	.	1	.	.	.	.	2	.	1	4	2
——— funatus	.	.	.	.	4	.	3	1	1	7	.	6	22	6*
——— qualteriatus	.	.	.	1	.	.	.	.	.	.	.	.	1	1
——— prænuntius, N. S.	.	.	.	.	2	.	.	.	1	.	.	3	6	3
——— sculptus	1	1	.	.	1	1	2	.	.	3	.	1	10	7*
——— tenuistriatus	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Littorina striatella	1	.	.	.	1	.	.	1	.	.	.	1	4	4
Loxonema sinuosa	1	.	.	.	2	.	.	.	.	.	.	2	5	3
Murchisonia corallii	.	.	.	.	.	2	.	.	.	5	1	4	12	4
——— articulata	1	.	.	.	1	.	2	.	.	4	.	1	9	5
——— polyglypha, N. S.	.	.	.	.	.	.	.	.	.	.	.	1	1	1
Natica parva	.	.	.	.	1	.	.	.	.	2	.	.	3	2
——— glaucinoides	.	.	.	.	.	1	.	.	.	1	.	.	2	2
Nerita prototypa	.	.	.	.	.	.	.	1	.	.	.	1	2	2
——— haliotis	3	.	.	.	3	.	3	.	1	5	.	4	19	6*
Patella implicata	.	.	.	.	.	.	1	.	1	.	1	.	3	3
Pileopsis vetustatis	1	.	.	.	.	.	.	.	.	.	.	.	1	1
Pleurotomaria angulata	.	.	.	.	1	.	.	1	.	.	.	.	2	2
——— balteata, N. S.	.	.	.	.	1	.	.	.	1	.	.	.	2	2
——— fissicarina, N. S.	.	.	.	.	.	.	.	.	.	.	.	1	1	1
——— Lloydii	1	1	.	.	.	.	3	.	2	3	.	3	13	6*
——— Pryceæ	.	.	1	.	2	.	.	1	.	.	.	1	5	4

[redacted]

TABLE XI.—*Geological Distribution of Gasteropoda in the Eastern Region.*

NAMES OF SPECIES.	STRATA IN DESCENDING ORDER.												No. of Occurrences of each Species.	No. of Strata in which each Species occurs.
	Downton Sandstone.	Upper Ludlow.	Aymestry Rock.	Lower Ludlow.	Wenlock Limestone.	Wenlock Shale.	Woolhope Limestone.	Caradoc Sandstone.	Caradoc Conglomerate.	Trap.	Black Shale.	Lowest Sandstone.		
Cyrtolites lævis	.	*	.	*	*	*	.	.	.	.	.	.	4	4
Euomphalus alatus	.	*	*	.	.	*	.	.	.	.	.	.	6	3
——— carinatus	.	*	.	.	.	.	.	.	.	.	.	.	2	1
——— Corndensis	.	.	.	.	.	.	.	*	.	.	.	.	1	1
——— discors	.	.	*	.	*	.	.	.	.	.	.	.	3	2
——— funatus	.	*	*	*	*	.	.	.	.	.	.	.	18	4
——— prænuntius, N. s.	.	.	.	.	.	.	.	*	.	.	.	.	4	1
——— sculptus	.	.	*	.	*	.	.	.	.	.	.	.	6	2
Littorina striatella	.	.	.	.	.	.	.	*	.	.	.	.	2	1
Loxonema sinuosa	.	.	*	.	*	*	.	*	.	.	.	.	5	4
Murchisonia corallii	.	*	.	.	.	.	.	.	.	.	.	.	10	1
——— articulata	.	*	*	.	.	.	.	.	.	.	.	.	5	2
——— polyglypha, N. s.	.	.	.	.	.	.	.	*	.	.	.	.	1	1
Natica parva	.	*	.	.	*	.	.	.	.	.	.	.	2	2
——— (glaucinoides, s. s.)	.	*	.	.	.	.	.	.	.	.	.	.	1	1
Nerita prototypa	.	.	.	.	*	.	.	.	.	.	.	.	2	1?
——— haliotis	.	*	*	.	*	*	*	.	.	.	.	.	13	4
Patella implicata	.	.	.	.	*	*	.	.	.	.	.	.	3	2
Pleurotomaria angulata	.	.	.	.	.	.	.	*	.	.	.	.	1	1
——— balteata, N. s.	.	.	.	.	*	.	.	.	.	.	.	.	1	1
——— fissicarina, N. s.	.	.	.	.	.	.	.	*	.	.	.	.	1	1
——— Lloydii	.	*	*	.	.	.	.	.	.	.	.	.	11	2
——— Pryceæ	.	.	.	.	.	.	.	*	*	.	.	.	2	2
——— quadristriata, N s.	.	.	*	.	.	.	.	.	.	.	.	.	1	1
——— undata	.	*	.	.	.	.	.	.	.	.	.	.	1	1
Trochus lenticularis	.	.	.	.	.	.	.	*	.	.	.	.	3	1
Turbo carinatus	.	*	.	.	.	.	.	.	.	.	.	.	1	1
——— cirrhosus	.	.	*	.	.	.	.	.	.	.	.	.	1	1
——— corallii	.	*	*	.	.	.	.	.	.	.	.	.	12	2
Turritella cancellata	.	.	.	.	.	.	.	*	*	.	.	.	3	2
——— gregaria	.	*	.	.	.	.	.	.	.	.	.	.	1	1
——— obsoleta	.	*	.	.	.	.	.	.	.	.	.	.	3	1
Number of Occurrences	.	49	26	2	26	7	1	16	3	.	.	.	130	.
No. of Species in each Stratum	.	15	10	2	10	4	1	10	2	.	.	.	.	.

LAMELLIBRANCHIATA.

The total number of Lamellibranchiate Conchifera yet found in the Lower Palæozoic strata is very small, and perhaps we may feel assured that this number is in some inverse proportion to the antiquity of the strata, the lowest rocks containing few or none. That they represent only a very small number of natural families is evident in all the classifications which have been proposed for them, and will appear still more clearly if the arrangement adopted in the following catalogue be approved.

The genus *Orthonota* of Conrad, as given in Hall's Geological Report on New York, undoubtedly includes '*Psammobia rigida*' of

the Silurian system, and some cognate forms; and Mr. Salter has been induced, by recent studies of the whole group of Silurian '*Cypricardiæ*,' to include them all in the same genus.* The affinities of the group always appeared to me, while examining them by thousands *in situ*, to point to that part of the series of *Dimyaria* where the *Unionidæ* and *Mytilacidæ* occur, and to constitute there a small and peculiar circle, with aberrations toward *Arcacidæ* (in what is here called *Actinodonta*), and (by species resembling *Allorisma* of King) toward the lutrariform shells so common in Mesozoic rocks. Professor Forbes regards these, as well as the so-called *Pullastræ* of the Silurian system, as definitely allied to *Modiola*, that is to say, *Mytilus*. If, as I suppose, *Cypricardia cymbæformis* be distinct, generically, and include species of the mountain limestone, the name *Goniophora* seems suitable. It is, however, doubtless, a mytiloid shell.

The *Arcacidæ* of the Silurian System are even more numerous than the lists indicate; but the forms of each species (e. g. *C. Cawdori*) are considerably variable, and the definition of them is difficult. The generic distribution in this catalogue is, we think, much amended, by placing in Hall's genus *Cleidophorus*,† the species (*Cucullæa* of the Silurian System) which are remarkable for the narrow vertical plate, the impression of which is so well figured by Mr. Sowerby in the plates of Murchison's 'Silurian System.'

We find the groups of *Mytilacidæ* and *Arcacidæ* to comprise nearly all the Dimyarian shells yet discovered in the Silurian strata of Wales and the bordering counties. The exceptions are *Cardium striatum* (Sil. Syst.), which is certainly not of that genus; *Cardiola* (Sil. Syst.), whose true place is undetermined, and *Pleurorhynchus*.

Still more confined is the series of *Monomyarian bivalves* of the Silurian rocks; for we have apparently only one natural family, that of the Aviculoid shells, the group which is nearest to *Dimyaria*.

As in almost every arrangement of the Lamellibranchiate shells, we

LAMELLIBRANCHIATA.

DIMYARIA.

PHOLADOMYIDÆ?

CARDIOLA FIBROSA.

REF.—Murchison, Sil. Syst., t. 8, f. 4.

Builth District . . . Builth, W. S.

CARDIOLA INTERRUPTA.

REF.—Murchison, Sil. Syst., t. 8, f. 5.

Malvern District . . Pound.
Abberley District . . Near Abberley Lodge, L.L.
Woolhope District . . South of Putley. Shucknall Hill, L.L.
Usk District . . . The Darran, A.L. Craig y garcyd.
Builth District . . . Cwm Craig ddu, U.L., L.L. Erw Gilfach, W.L. Builth, W.S. Neuadd Llwyd. Carneddau, L.F.

CARDIOLA STRIATA.

REF.—*Cardium striatum*, Murchison, Sil. Syst., t. 6, f. 2.

Malvern District . . Chance's Pitch. Hereford Beacon Quarry.
Woolhope District . . Prior's Court. Shucknall Hill. Bodenham, A.L. Dormington Wood.
Usk District . . . Llanbadoc, Lancayo, A.L. Llangibby, U.L.

Cardiaceæ.

PLEURORHYNCHUS ÆQUICOSTATUS, Phillips.

REF.—Palæontological Appendix.

Woolhope District . . Dormington Wood (one specimen).

MYTILACIDÆ?

ORTHONOTA AMYGDALINA.

REF.—*Cypricardia? amygdalina*, Murchison, Sil. Syst., t. 5. f. 2.

Malvern District . . Frith Farm. Mathon. Pound. Chance's Pitch.
Abberley District . . Barrell Hill. Walgrove. Hole Farm. Hillside Farm.
Woolhope District . . Pilliard's Barn. Stoke Edith. Welsh Court. Shucknall Hill. Perton. Ecknall Copse.
May Hill District . . West of Rock Farm. Longhope.
Usk District . . . Usk Castle. Pentopin. Llangibby. Lancayo. Cefn Ila. Clytha Castle. South of Radyr.
Builth District . . . Blaenau. Henllyn Hill. Cwm Craig ddu.
Llandilo District . . Swansea Road, 4. Pont ar y llechau. Myddelton Park.

ORTHONOTA CINGULATA, Hising. *sp.*

REF.—Palæontological Appendix.

Usk District . . . Llangibby, U.L. Llanbadoc, Darren, A.L.

Llandilo District . . Llechclawdd. Swansea Road, 4, 8. Dafaddfa Uchaf, N. Storm Hill Lodge. South of Carreg Llwyd. Pont ar y llechau. Myddelton Hall.

ORTHONOTA EXTRASULCATA, Salter.

REF.—Palæontological Appendix.

Llandilo District . . Dafaddfa Uchaf.

ORTHONOTA IMPRESSA.

REF.—*Cypricardia impressa*, Murchison, Sil. Syst., t. 5, f. 3.

Malvern District . . Mathon.
Usk District . . . Usk Castle. Llangibby, A.L.
Llandilo District . . North of Trichrug. Storm Hill Lodge.
Freshwater District . . Freshwater East.
Marloes District . . Wooltack Bay. Marloes Bay, 1. Marloes Mill.

ORTHONOTA INORNATA, Phillips.

REF.—Palæontological Appendix. Comp. *Orthonota undulata*, Conrad; Hall's 'Geology of New York,' p. 205.

Marloes District . . Marloes Bay, 3 a.

ORTHONOTA RETUSA.

REF.—*Cypricardia? retusa*, Murchison, Sil. Syst., t. 5, f. 5.

Malvern District . . Pound. Coomb Hill. Overley.
Woolhope District . . Hazle. Welsh Court.
May Hill District . . S.W. of Hobbs.
Usk District . . . Usk Castle. Cefn Ila Lodge.
Marloes District . . Marloes Bay, 1.

ORTHONOTA RIGIDA.

REF.—*Psammobia rigida*, Murchison, Sil. Syst., t. 8, f. 3. Paleont. Appendix.

Malvern District . . Brock Hill.
Abberley District . . Hole Farm.

ORTHONOTA SOLENOIDES.

REF.—*Cypricardia solenoides*, Murchison, Sil. Syst., t. 8, f. 2.

Malvern District . . Brock Hill.
Abberley District . . Abberley (Murch.). Hole Farm.
Woolhope District . . Stoke Edith.
Usk District . . . Bryn Craig.

ORTHONOTA TRIANGULATA, Salter.

REF.—Palæontological Appendix.

Llandilo District . . Llechclawdd.

MYTILACIDÆ, TRUE.

GONIOPHORA CYMBÆFORMIS.

REF.—*Cypricardia ? cymbæformis*, Murchison, Sil. Syst., t. 3, f. 10 a.
Cardites carpomorphus, Dalman ?

Malvern District . . Hale's End, Mathon. Hope End.
Abberley District . . Barrell Hill. Walgrove.
Woolhope District . . Wonder. Putley. Perton.
May Hill District . . West of Rock Farm. Longhope.
Usk District . . . Usk Castle, U. L. Llangibby. Llanfrechfa. Craig y garcyd.
Builth District . . . Pwll ddu, U.L. Cwm Craig ddu, U.L.
Llandilo District . . Horeb Chapel. Myddelton Hall.
Marloes District . . Marloes Bay, 3.

MYTILUS ANTIQUUS.

REF.—*Modiola antiqua*, Murchison, Sil. Syst., t. 13, f. 1.

May Hill District . . East side of May Hill, W. S.

MYTILUS COMPLANATUS.

REF.—*Pullastra complanata*, Sil. Syst., t. 5, f. 7.

Usk District . . . Bryn Craig. Llangibby, U.L. Darren. Llanfrechfa.
Llandilo District . . Golden Grove, 4. Swansea Road, 8. Dafaddfa Uchaf, S. South of Trichrug. North of Trichrug.
Freshwater District . . Freshwater East (S.)

MYTILUS EXASPERATUS, Phillips.

REF.—Palæontological Appendix.

Llandilo District . . Swansea Road, 8.

MYTILUS GRADATUS, Salter.

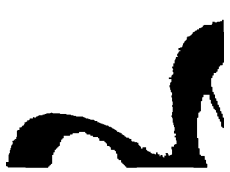
REF.—Palæontological Appendix.

Abberley District . . Hole Farm, L.L.
Usk District . . . Bryn Craig?
Llandilo District . . Golden Grove, 4. Swansea Road, 8.

MYTILUS LÆVIS.

REF.— *Pullastra lævis*, Murchison, Sil. Syst., t. 3, f. 1 a.

Llandilo District . . Horeb Chapel (Murch.)



MYTILUS MYTILIMERIS?

Syn.—*Inocer. Mytilimeris*, Conrad, 'Journ. Acad. Nat. Sc.,' Philad., vol. viii. pt. 1, Pl. 13, f. 10?

Usk District . . . Craig y Garcyd.
Llandilo District . . Myddelton Hall. Golden Grove, 4.

MYTILUS PEROVALIS, Salter.

REF.—Palæontological Appendix.

Usk District . . . Llanbadoc, A.L.

MYTILUS PLATYPHYLLUS, Salter.

REF.—Palæontological Appendix.

Llandilo District . . Dafaddfa Uchaf.

MYTILUS QUADRATUS, Salter.

REF.—Palæontological Appendix.

Llandilo District . . Dafaddfa Uchaf.

MYTILUS? UNGUICULATUS, Salter.

REF.—Palæontological Appendix.

Usk District . . . Bryn Craig.

ARCACIDÆ.

ACTINODONTA CUNEATA, Phillips.

REF.—Palæontological Appendix.

Haverfordwest District . Priory Mill.
Marloes District . . Marloes Bay, 3 a.

ARCA PRIMITIVA, Phillips.

REF.—Palæontological Appendix.

Freshwater District . Freshwater East, S.

CLEIDOPHORUS ANTIQUUS.

REF.—*Cucullæa antiqua*, Murchison, Sil. Syst., t. 3, f. 1 b and 12 a.

Malvern District . . Coomb Hill. Frith Farm.

CLEIDOPHORUS OVATUS.

REF.—*Cucullæa ovata*, Murchison, Sil. Syst., t. 3, f. 12 b.

Abberley District	. Hole Farm. Hill Side Farm.
Usk District	. Usk Castle.
Llandilo District	. Swansea Road. Storm Hill Lodge. Horeb Chapel (Murch.) Golden Grove. Keeper's Lodge.
Freshwater District	. Freshwater East, S.

CLEIDOPHORUS CAWDORI.

REF.—*Cucullæa Cawdori*, Murchison, Sil. Syst., t. 3, f. 11.

Malvern District	. Overley.
Usk District	. South of Radyr. Llanbadoc, A.L.
Marloes District	. Marloes Bay, 1, H.
Freshwater District	. Freshwater East.

NUCULA COARCTATA, Phillips.

REF.—Palæontological Appendix.

Freshwater District	. Freshwater East, S.

NUCULA LÆVIS.

REF.—Murchison, Sil. Syst., t. 22, f. 1.

Caermarthen District	. Pensarn, near Caermarthen (Murch.)

NUCULA OVALIS.

REF.—Murchison, Sil. Syst., t. 5, f. 8.

Malvern District	. Coomb Hill. Mathon. Overley. Halesend. Brock Hill, U.L.
Woolhope District	. Shucknall Farm.
Usk District	. Usk Castle.
Llandilo District	. Pont ar y llechau.

NUCULA SULCATA.

REF.—Hisinger, *Lethæa Suec.*, Suppl., Pl. 40, f. 2.

Usk District	. Bryn Craig.
Builth District	. Aberedw, U.L. Builth, W.
Llandilo District	. Myddelton Hall. Golden Grove, 2. Swansea Road, 6.
Marloes District	. Slate Mill. Marloes Bay.

MONOMYARIA.

AVICULA AMPLIATA, Phillips.

REF.—Palæontological Appendix.

Usk District . . . Cefn Ila? L.L.
Llandilo District . . North of Trichrug. Golden Grove, 2.

AVICULA? PLANULATA.

REF.—*Pterinea planulata*, Conrad. Palæontological Appendix.

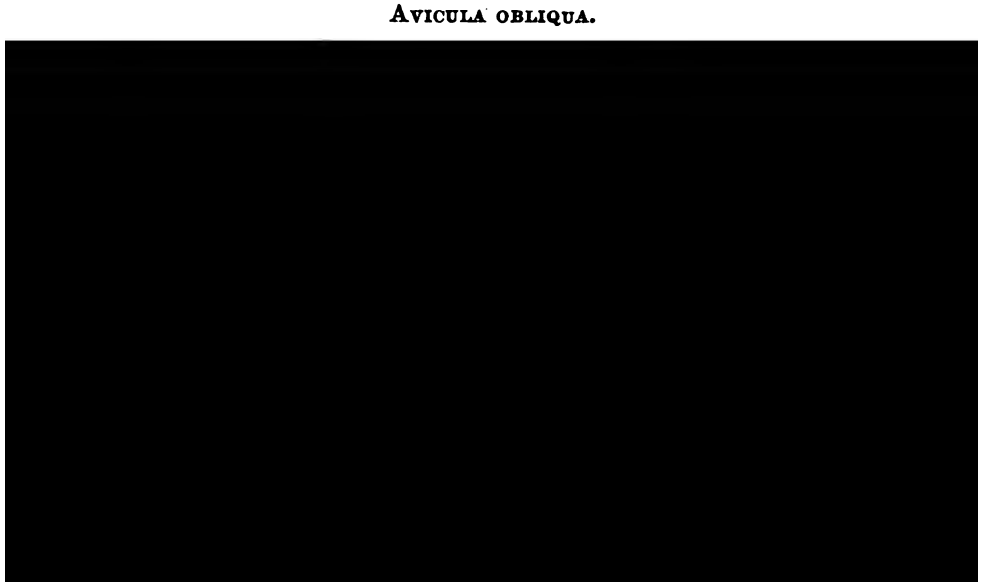
Malvern District . . Clincher's Mill.
Abberley District . . Callow Farm.
Woolhope District . . South of Dormington Wood.
May Hill District . . Rock.
Usk District . . . South of Radyr. Llanbadoc, A.L. Craig y Garcyd. Bryn Craig.
Llandilo District . Myddelton Hall.

AVICULA LINEATA.

REF.—Murchison, Sil. Syst., t. 5, f. 10.

Malvern District . . Overley. Halesend. Mathon. Frith Farm.
Abberley District . . Barrell Hill. Hole Farm.
Woolhope District . . Stoke Edith. Pilliard's Barn. Bodenham. Dormington Wood.
Usk District . . . Llanfrechfa. North of Camp Wood. Cefn Ila, L.L. Coed y Pan, Darren. Ty Newydd. Pentopin. Trostra. Usk Castle. Llanbadoc. Bryn Craig. Craig y Garcyd.
Llandilo District . . Ty newydd. Swansea Road, 8, 4. Gilfach. Golden Grove, 4. Pont ar y llechau.
Marloes District . . Slate Mill, Lindsway.

AVICULA OBLIQUA.



AVICULA RECTANGULARIS.

REF.—Murchison, Sil. Syst., t. 3, f. 2.

Malvern District	. Halesend.
Woolhope District	. Welsh Court.
May Hill District	. West of Rock Farm.
Usk District	. Llanfrechfa.
Llandilo District	. Horeb Chapel (Murch.)

AVICULA RETICULATA.

REF.—Murchison, Sil. Syst., t. 6, f. 3.

Malvern District	. Pound.
Woolhope District	. Bodenham, A.L.
Usk District	. Llanbadoc.
Tortworth District	. Falfield, Tortworth (Murch.)
Llandilo District	. Nelson's Tower Wood. Myddelton Park.
Marloes District	. Slate Mill. Lindsway.

AVICULA RETROFLEXA.

REF.—Murchison, Sil. Syst., f. 5, t. 9.

Malvern District	. Ledbury.
Abberley District	. Hole Farm. Hill End.
Woolhope District	. Wonder. Pilliard's Barn Hazle. Stoke Edith. Backbury Camp. Echnall Copse. Welsh Court. Shucknall Farm. Bodenham.
May Hill District	. S.W. of Hobbs.
Usk District	. Llangibby, U.L. Darren. Llanfrechfa. Beech Hill Farm, A.L. Cefn Ila, L.L.? Usk Castle. Llanbadoc. Ty Newydd. Craig y Garcyd. Bryn Graig.
Builth District	. Henllyn Hill, U.L.
Llandilo District	. Horeb Chapel. Mandinam. Dafaddfa Uchaf, S. Pont ar y llechau. Golden Grove, 2. Myddelton Park. Golden Grove, 4.
Marloes District	. Marloes Bay, H.

TABLE XII.—*Geographical Distribution of Lamellibranchiata.*

NAMES OF SPECIES.	Western Districts.						Eastern Districts.						No. of Occurrences of each Species.	No. of Districts in which each Species occurs.
	Marloes.	Freshwater.	Haverfordwest.	Caermarthen.	Llandilo.	Builth.	Usk.	Tortworth.	May Hill.	Woolhope.	Abberley.	Malvern.		
Dimyaria.														
Cardiola fibrosa	.	.	.	.	.	1	.	.	.	.	.	.	1	1
——— interrupta	.	.	.	.	.	5	2	.	.	2	1	1	11	5
——— striata	.	.	.	.	.	.	3	.	.	4	.	2	9	3
Pleurorhynchus æquicostatus	.	.	.	.	.	.	.	.	.	1	.	.	1	1
Goniophora cymbæformis	1	.	.	.	2	2	4	.	2	3	2	3	19	8
Orthonota amygdalina	.	.	.	.	3	3	7	.	2	6	4	4	29	7
——— cingulata	.	.	.	.	8	.	3	.	.	.	.	.	11	2
——— extrasulcata	.	.	.	.	1	.	.	.	.	.	.	.	1	1
——— impressa	3	1	.	.	2	.	2	.	.	.	.	1	9	5
——— inornata	1	.	.	.	.	.	.	.	.	.	.	.	1	1
——— retusa	1	.	.	.	.	.	2	.	1	2	.	3	9	5
——— rigida	.	.	.	.	2	.	.	.	1	.	1	1	5	4
——— rotundata	.	.	.	.	2	.	.	.	1	1	1	.	5	4
——— semisulcata	.	.	.	.	1	.	.	.	.	2	.	.	3	2
——— solenoides	.	.	.	.	.	.	1	.	.	1	2	1	5	4
——— triangulata	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Mytilus antiquus	.	.	.	.	.	.	.	.	1	.	.	.	1	1
——— complanatus	.	1	.	.	5	.	4	.	.	.	.	.	10	3
——— exasperatus	.	.	.	.	1	.	.	.	.	.	.	.	1	1
——— gradatus	.	.	.	.	2	.	1	.	.	.	1	.	4	3
——— lævis	.	.	.	.	1	.	.	.	.	.	.	.	1	1
——— mytilimeris	.	.	.	.	2	.	2	.	.	.	.	1	5	3
——— platyphyllus	.	.	.	.	4	.	.	.	.	.	.	.	4	1
——— perovalis	.	.	.	.	.	.	1	.	.	1	.	.	2	2
——— quadratus	.	.	.	.	1	.	.	.	.	.	.	.	1	1
——— unguiculatus	.	.	.	.	.	.	1	.	.	.	.	.	1	1
Actinodonta cuneata	1	.	1	.	.	.	.	.	.	.	.	.	2	2
Arca primitiva	.	1	.	.	.	.	.	.	.	.	.	.	1	1
Cleidophorus antiquus	.	1	.	.	5	.	4	.	.	2	2	2	16	6
——— Eastnori	.	.	.	.	1	.	.	.	.	.	.	3	4	2
——— ovatus	.	1	.	.	4	.	1	.	.	.	2	.	8	4
——— Cawdori	1	1	.	.	.	.	2	.	.	.	.	1	5	4
Nucula coarctata	.	1	.	.	.	.	.	.	.	.	.	.	1	1
——— lævis	.	.	.	1	.	.	.	.	.	.	.	.	1	1
——— ovalis	.	.	.	.	1	.	1	.	.	1	.	5	8	4
——— sulcata	2	.	.	.	3	2	1	.	.	.	.	.	8	4
Monomyaria.														
Avicula ampliata	.	.	.	.	2	.	1	.	.	.	.	.	3	2
——— planulata	.	.	.	.	1	.	4	.	1	1	1	1	9	6
——— lineata	2	.	.	.	6	.	12	.	.	4	2	4	30	6
——— obliqua	.	.	.	.	2	.	.	.	.	.	.	1	3	2
——— orbicularis	2	.	.	.	3	.	.	.	.	.	.	2	7	2

and others. The most abundant of all appears to be *Avicula retroflexa*, which is marked †. As in the case of the Crustacea (p. 241), the Llandilo district proves to be the richest. It is, however, though a very large district, only a little superior in species to the smaller areas of Usk and Malvern. It is remarkable that only the three families of Mytiloid, Arcoid, and Aviculoid shells have yet been found west of the region of Builth; the *Cardiolæ* and *Pleurorhynchi* appear to be eastern forms. The districts of Usk and Llandilo have the most complete suite of Mytiloid shells; the *Arcacidæ* are most numerous in the Malvern district; the *Aviculæ* arrive at a maximum about Llandilo.

Considered generally, the geographical distribution of the Lamellibranchiata is more similar to that of the Cephalopoda (p. 251) than to that of the Crustacea (p. 241).

TABLE XIII.—*Geological Distribution of Lamellibranchiata in the Eastern Region.*

Names of Species.	Strata in Descending Order.												No. of Occurrences of each Species.	No. of Strata in which each Species occurs.
	Downton Sandstone.	Upper Ludlow.	Aymestry Rock.	Lower Ludlow.	Wenlock Limestone.	Wenlock Shale.	Woolhope Limestone.	Upper Caradoc.	Lower Caradoc.	Trap.	Black Shale.	Lowest Sandstone.		
Cardiola interrupta	.	*	*	*	.	*	.	.	.	.	.	.	6	4
—— striata	.	*	*	.	*	.	.	.	.	.	.	.	9	3
Pleurorhynchus æquicostatus	.	.	.	.	*	.	.	.	.	.	.	.	1	1
Orthonota amygdalina	.	*	.	.	.	.	.	.	.	.	.	.	23	1
—— cingulata	.	*	*	.	.	.	.	.	.	.	.	.	3	2
—— impressa	.	*	*	.	.	.	.	.	.	.	.	.	3	2
—— retusa	.	*	.	.	.	.	.	.	.	.	.	.	8	1
—— rigida	.	*	.	*	*	.	.	.	.	.	.	.	3	3
—— rotundata	.	*	*	*	.	.	.	.	.	.	.	.	3	3
—— semisulcata	.	.	*	.	.	.	.	.	.	.	.	.	2	1
—— solenoides	.	*	.	*	*	*	.	.	.	.	.	.	5	4
Goniophora cymbæformis	.	*	.	.	*	.	.	.	.	.	.	.	14	2
Mytilus antiquus	.	.	.	.	.	*	.	.	.	.	.	.	1	1
—— complanatus	.	*	.	.	.	*	.	.	.	.	.	.	4	2
—— gradatus	.	.	.	*	.	*	.	.	.	.	.	.	2	2
—— mytilimeris	.	.	.	.	.	*	.	.	.	.	.	.	1	2
—— perovalis	.	.	*	.	.	.	.	.	.	.	.	.	1	1
—— unguiculatus	.	.	.	.	.	*	.	.	.	.	.	.	1	1
Cleidophorus antiquus	.	*	*	.	.	*	.	.	.	.	.	.	10	3
—— Eastnori	.	.	.	.	.	.	.	*	*	.	.	.	3	2
—— ovatus	.	*	.	*	.	.	.	.	.	.	.	.	3	2
—— Cawdori	.	*	*	.	.	.	.	.	.	.	*	.	3	2
Nucula ovalis	.	*	.	.	.	.	.	.	.	.	.	.	5	1
—— sulcata	.	.	.	.	.	*	.	.	.	.	.	.	1	1
Avicula ampliata	.	.	.	*	.	.	.	.	.	.	.	.	1	1
—— planulata	.	.	*	.	*	*	.	.	.	.	.	.	8	3
—— lineata	.	*	.	*	*	*	.	.	.	.	.	.	10	4
—— obliqua	.	.	.	.	.	.	.	.	*	.	.	.	1	1
—— orbicularis	.	.	.	.	.	.	.	.	*	.	.	.	2	1
—— rectangularis	.	*	.	.	.	.	.	.	.	.	.	.	3	1
—— reticulata	.	*	*	.	*	.	.	.	.	.	.	.	5	3
—— retroflexa	.	*	*	*	*	*	.	.	.	.	.	.	23	5**
No. of Species in each Stratum	.	19	12	9	9	12	.	1	3	.	.	.	.	.
		In Upper Silurian, 7 species.						In Lower Silurian, 29 species.						

In this table no instance occurs of a species which extends through the Lower and Upper Silurian beds. In the Lower Silurian strata only *Arcaceæ* and *Aviculæ* are mentioned. There is, however, at least one Mytiloid shell in the Lower Caradoc, and I have casts which indicate a Tubicolar bivalve in the same. *Avicula retroflexa*, which is the most abundant form, has been found in more strata than the others. Not one species is quoted from the Woolhope Limestone, or the Downton Sandstone. The number of species is greatest in the Upper Ludlow rocks, which are the great repository for *Orthonotæ*, though but few of them are really confined to these strata.

TABLE XIV.—*Geological Distribution of Lamellibranchiata in the Llandilo Region.*

NAMES OF SPECIES.	STRATA IN DESCENDING ORDER.		
	Tilestone Bands.	Mydelton Group.	Llandilo Limestone Series.
Goniophora cymbæformis	*	*	..
Orthonota amygdalina	..	*	..
——— cingulata	*	*	..
——— extrasulcata	*	..	..
——— impressa	*	*	..
——— rigida	..	*	..
——— rotundata	..	*	..
——— semisulcata	..	*	..
——— triangulata	*	..	..
Mytilus complanatus	*	*	..
——— exasperatus	..	*	..
——— gradatus	..	*	..
——— lævis	*	..	..
——— mytilimeris	..	*	..
——— platyphyllus	*	..	..
——— quadratus	*	..	..
Cleidophorus antiquus	*	*	..
——— Eastnori	..	*	..
——— ovatus	*	*	..
Nucula ovalis	..	*	..

plunged in the mineral sequence of Old Red, contains truly Silurian life, and corresponds to the upper part of the Ludlow Series of Builth. 23 out of the 29 species included in the table are found in the eastern region. Of these, three, viz., *Cleidophorus Eastnori*, *Avicula obliqua*, and *A. orbicularis*, occur there in Lower Silurian strata.

Regarded generally, in all the Silurian regions, from Malvern to St. Bride's Bay, the frequency of Lamellibranchiata characterizes Upper Silurian rocks: the *Arcacidæ*, however, appear locally predominant in the sandy Lower Silurians of Malvern.

BRACHIOPODA.

Lingula attenuata.

Ref.—Murchison, Sil. Syst., t. 22, f. 13.—See Palæontological Appendix.

Malvern District . . Under Worcester Beacon, U.C. Storridge, L.C. Cowley Park. Obelisk.
Abberley District . . Ankerdine Hill, U.C.
Builth District . . . Carneddau.

Lingula cornea.

Ref.—Murchison, Sil. System, t. 3, f. 3.

Abberley District . . Walgrove.
Woolhope District . . Stoke Edith.

Lingula crumena, Phillips.

Ref.—Palæontological Appendix.

Malvern District . . Howler's Heath.

Lingula granulata, Phillips.

Ref.—Palæontological Appendix.

Llandilo District . . Llandilo, L.S. N.W. of Gwenllwyn. Tregib.
Haverfordwest District . Mydrim, L.S. Lann Mill.

Lingula lata?

Ref.—Murchison, Sil. Syst., t. 8, f. 11.

Abberley District . . Hole Farm, L.L.

Lingula Lewisii.

Ref.—Murchison, Sil. Syst., t. 6, f. 9.

Malvern District . . West of Rilbury, A.L.
Abberley District . . Ankerdine Hill, A.L. Hole Farm, L.L.
Woolhope District . . S. of Putley, A. L. Shucknall Hill, A. L. Ecknall Copse. Bodenham, A.L.
Usk District . . . Usk. Cilfigan. Tucking Mill.
Llandilo District . . Cilmaen llwyd.
Freshwater District . Freshwater East.

LINGULA MINIMA.

REF.—Murchison, Sil. Syst., t. 5, f. 23.

Malvern District . . Brock Hill, D.S.

LINGULA PARALLELA, Phillips.

REF.—Palæontological Appendix.

Malvern District . . Gunwick Mill, U.C.

Note.—A large elongated species of Lingula occurs in the Marloes district (near the conglomerate,) at the base of the section in Marloes Bay. A very minute species in graptolite schists, near Modrim.

ORBICULA PUNCTATA.

REF.—Murchison, Sil. Syst., t. 20, f. 5.

Marloes District . . Wooltack.

ORBICULA RUGATA.

REF.—Murchison, Sil. Syst., t. 5, f. 11.

Malvern District . . Overley. Hale's End. Mathon Coomb. Frith Hall Court.

Abberley District . . Ankerdine Hill, A.L. Barrell Hill. Hole Farm. Wallgrove. Hillside Farm.

Woolhope District . . Welsh Court. Shucknall Farm. Shucknall Hill. Wonder. Old Sutton, Perton, &c. N.E. of Pilliard's Barn. Bodenham, U.L., A.L.

May Hill District . . Longhope, &c.

Tortworth District . . Pyrton Passage.

Usk District . . . Usk Castle. Llanbadoc, A.L.

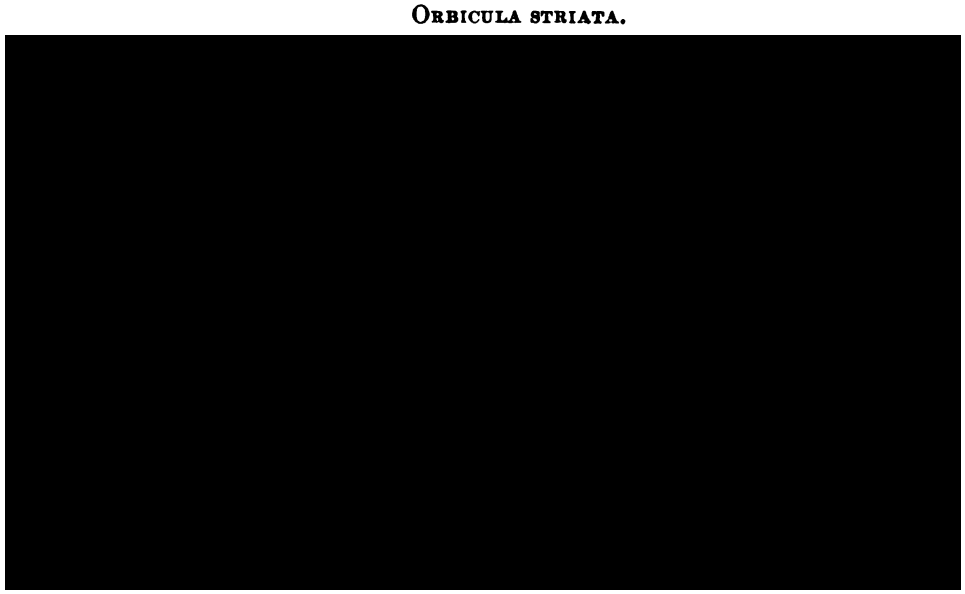
Builth District . . . Henllyn. Pengarreg.

ORBICULA CORRUGATA.

REF.—Hall. Geology of New York, p. 108.

Woolhope District . . Dormington Wood, W.L.

ORBICULA STRIATA.



ATRYPA DEPRESSA.

REF.—Murchison, Sil. Syst., t. 13, f. 6.

Malvern District . . Stump's Wood. Storridge.
Llandilo District . . Castell craig gwyddon.

ATRYPA DIDYMA (including Ter. Canalis).

REF.—Murchison, Sil. Syst., t. 6, f. 4.

Abberley District . . Ridge Hill, A.L.
Woolhope District . . S.W. of Hazle. Wootton Farm.
Usk District . . . Usk, U.L. Llangibby. North of Camp Wood. Llangibby, A.L. Dowlas, L.L.
Builth District . . . Cwm craig ddu, U.L.
Llandilo District . . Dafaddfa-Uchaf, S. North of Trichrug. Storm Hill Lodge. Pont ar y llechau. Golden Grove, M.S.

ATRYPA GLOBOSA.

REF.—Murchison, Sil. Syst., t. 22, f. 26.

Malvern District . . Worcester Beacon, U.C.
Llandilo District . . Castell Craig Gwyddon. Allt ddu. Plas Bach. Golden Grove. Swansea Road.
Marloes District . . Wooltack Bay.

ATRYPA HEMISPHERICA.

REF.—Murchison, Sil. Syst., t. 20, f. 7.

Malvern District . . Gunwick Mill. Worcester Beacon.
Abberley District . . Ankerdine Hill, U.C. (abundant).
May Hill District . . May Hill. Huntley Hill.
Haverfordwest District . Shole's Hook.
Marloes District . . Wooltack Bay.

ATRYPA LENS.

REF.—Murchison, Sil. Syst., t. 21, f. 3.

Malvern District . . Wych. Fair Oaks. Worcester Beacon. Howler's Heath. Gunwick Mill. Gullet Wood.
May Hill District . . May Hill. Huntley Hill.
Llandilo District . . Tynewydd. Mandinam. Goleugoed.
Haverfordwest District . Priory Mill.

ATRYPA LINGUIFERA.

REF.—Murchison, Sil. Syst., t. 13, f. 8.

Malvern District . . Under Worcester Beacon. Storridge. Brock Hill Section.
Woolhope District . . South of Woolhope. Wootton Farm. Dormington Wood.
May Hill District . . Between Rock and Dursley.

ATRYPA OBOVATA.

REF.—Murchison, Sil. Syst., t. 8, f. 8, 9.

Malvern District . . Mathon Lodge. Dog Hill.
Woolhope District . . Wootton Farm.
Marloes District . . Marloes Bay.

ATRYPA RETICULARIS, Linn. (*prisca* Dalm. *affinis* Sow.).

REF.—*Atrypa affinis*, Murch., Sil. Syst., t. 6. f. 5; and *A. aspera*, Sil. Syst., t. 12, f. 5.

Malvern District . . Brock Hill Section. Under Worcester Beacon. Pound. Storridge. Hope End. Hereford Beacon. Ledbury. Eastnor Park. West of Rilbury. Clincher's Mill. Dunbridge Wood. Howler's Heath. Gold Hill Farm. Eastnor Castle.

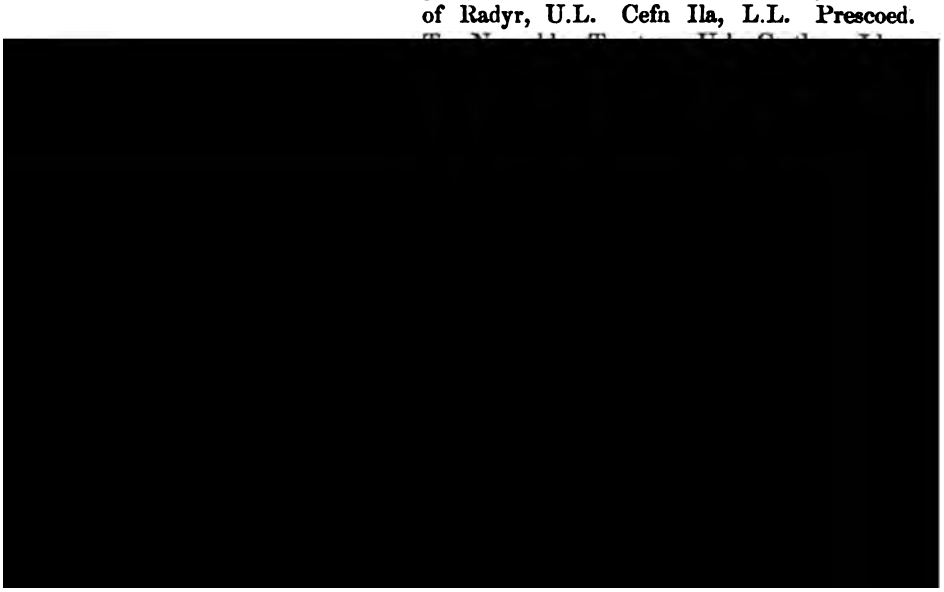
Abberley District . Ankerdine Hill, W.L. Hill End. Ridge Hill, A.L. Walgrove Hill, L.L. Martley Road, L.L. North of Hill End, W.L. Abberley. Callow Farm. Collin's Green, L.L. Hole Farm.

Woolhope District . . Stoke Edith. Backbury Camp, A.L. Pilliard's Barn. Hazle. Prior's Court. Welsh Court. South of Putley. Shucknall Hill, A.L. Bodenham, A.L. North of Canwood. Lindels. Dormington Wood. East of Canwood. Checkley Common. South of Woolhope. Littlehope. Haugh Wood.

May Hill District . . West of Rock Farm. Rock. South of Rock Farm. North of Taynton. Huntley Hill. May Hill.

Tortworth District . . Horse Shoe Farm.

Usk District . . . Usk, U.L. Llanbadoc, A.L. Lancayo. Llangibby. Russell's Farm. Near Radyr. S.E. of Radyr, U.L. Cefn Ila, L.L. Prescoed.



ATRYPA RETICULARIS, var. ORBICULARIS.

REF.—Murchison, Sil. Syst., t. 19, f. 3, 4.

Malvern District . . Worcester Beacon. Howler's Heath. Obelisk. Wych. Gunwick Mill.
May Hill District . . May Hill. Huntley. S.E. of May Hill.
Llandilo District . . Swansea Road. Golden Grove. Myddelton Hall.
Marloes District . . Slate Mill. Hooton.

ATRYPA ROTUNDA.

REF.—Murchison, Sil. Syst., t. 13, f. 7.

Malvern District . . Storridge.

ATRYPA TUMIDA, Dalm.

REF.—*A. tenuistriata*, Murchison, Sil. Syst., t. 12, f. 3.

Malvern District . . Storridge. Ledbury. Hereford Beacon. Eastnor Park.
Abberley District . . Hill End, W.L., L.L. Abberley, W.L. Callow Farm.
Woolhope District . . North of Canwood. Dormington Wood. East of Canwood. Lindels.
May Hill District . . West of Rock Farm. Rock Farm. North of Taynton.
Usk District . . . Llanbadoc, A.L. Russell's Farm, A.L. Cilfigan. Ty Newydd. Trostra. Bryn Craig. Craig y garcyd.
Llandilo District . . Ty Newydd. Keeper's Lodge. Rhiwgoch.

ATRYPA UNDATA.

REF.—Murchison, Sil. Syst., t. 21, f. 2.

Malvern District . . Under Worcester Beacon, U.C.
May Hill District . . May Hill. Huntley Hill.
Llandilo District . . Pen y lan. Mandinam. Castell craig gwyddon. Goleugoed. Cefn y garreg.
Haverfordwest District . Priory Mill. Robeston Wathen.

HYPOTHYRIS BIDENTATA.

REF.—Murchison, Sil. Syst., t. 12, f. 13 a.

Abberley District . . Abberley (Murchison), W.L.
Woolhope District . . Dormington Wood.
Usk District . . . Bryn Craig. Tucking Mill.
Llandilo District . . Myddelton Hall, M.S. Golden Grove, 4.

HYPOTHYRIS BOREALIS.

REF.—*T. lacunosa*, Sil. Syst., t. 12, f. 10.

Malvern District . . Hope End, U.L. Frith Pound. Mathon.
Abberley District . . Abberley, W.L. Callow Farm.
Woolhope District . . Hazle, U.L. Wonder. Pilliard's Barn. Stoke Edith. Shucknall.

May Hill District . . West of Rock Farm, U.L. Rock Farm. South of Rock.
Usk District . . . Russell's Farm, A.L. Llangibby. Dowlas Farm. Craig y garcyd.
Llandilo District . . Golden Grove, M.S., 2.
Freshwater District . Freshwater East.
Marloes District . . Marloes Bay, M.S.

HYPOTHYRIS BREVIROSTRIS.

REF.—Murchison, Sil. Syst., t. 13, f. 15.

Malvern District . . Croft, W.S.
Woolhope District . . Woolhope (Murchison), W.S.

HYPOTHYRIS CRISPATA.

REF.—Murchison, Sil. Syst., t. 12, f. 11.

Woolhope District . . Dormington Wood, W. L. North of Canwood, WP.L. Littlehope.
Llandilo District . . Keeper's Lodge.

HYPOTHYRIS CUNEATA.

REF.—Murchison, Sil. Syst., t. 12, f. 13.

Abberley District . . Hill End, W.L. Callow Farm.
Woolhope District . . Dormington Wood, W.L.
May Hill District . . Rock, W.L.

HYPOTHYRIS DECEMPLICATA.

REF.—Murchison, Sil. Syst., t. 21, f. 17.

Malvern District . . Under Worcester Beacon, WP.L. Wych, U.C. Worcester Beacon, L.C. Obelisk. Cowley Park.
Abberley District . . Ankerdine Hill, U.C.
Haverfordwest District . Lampeter Hill, M.S.
Marloes District . . Marloes Bay, M.S.

HYPOTHYRIS MARGINALIS, Dalm.

REF.—*Tereb. imbricata*, Murchison, Sil. Syst., t. 12, f. 12.

Malvern District . .	Storridge, W.L., WP. L. Worcester Beacon, WP. L.
Woolhope District . .	Dormington Wood.
May Hill District . .	Between Rock and Dursley Cross. Rock Farm.
Usk District . . .	Craig y garcyd.
Llandilo District . .	Goleugoed. Cerrig gwynion. Cefn Rhyddan. Tregib.

HYPOTHYRIS INTERPLICATA.

REF.—Murchison, Sil. Syst., t. 13, f. 23.

Woolhope District . .	Woolhope (Murchison), W. S.

HYPOTHYRIS NAVICULA.

REF.—Murchison, Sil. Syst., t. 5, f. 17.

Malvern District . .	Overley, U.L. Hales End.
Woolhope District . .	Near Hazle. Shucknall Farm. Bodenham, A.L.
Tortworth District . .	Pyrton Passage, U.L.
Usk District . . .	Usk Castle, U.L. South of Radyr. North of Camp Wood. Llanbadoc, A.L. Darran. Cefn Ila, L.L. Ysgubor Gwynt.
Builth District . . .	Aberedw, U.L., A.L. Cwm Craig ddu, U.L., A.L., L.L. Erw Gilfach. Coryn. Presteign Road, W.S.
Llandilo District . .	Pont ar y llechau, M.S. Llangwm.

HYPOTHYRIS NUCULA.

REF.—Murchison, Sil. Syst., t. 5, f. 20.

Malvern District . .	Overley, U.L. Brock Hill. Hale's End. Mathon. Pound. Coomb. Frith. Hall Court. Rilbury, A.L. Eastnor Castle, W.L. Awkbridge Farm. Clincher's Mill.
Abberley District . .	Ankerdine Hill, U.L. Hill End.
Woolhope District . .	South of Putley, U.L. Prior's Court. Welsh Court. Stoke Edith, Backbury Camp, A.L. North of Canwood, W.L. Lindels. Dormington Wood.
May Hill District . .	West of Rock Farm, U.L. S.W. of Hobbs.
Freshwater District .	Newton Quarry, M.S.

HYPOTHYRIS PULCHRA.

REF.—Murchison, Sil. Syst., t. 5, f. 21.

Malvern District . .	West side of Malvern Hills, U.L. (Murchison).

HYPOTHYRIS SEMISULCATA.

REF.—*T. semisulcata*, Dalm. (*lacunosa*, Sil. Syst., pl. 5. f. 19.)

Abberley District . .	Barrell Hill. Walgrove. Hole Farm. Hill End. Ridge Hill. Callow Farm.

Woolhope District . . Welsh Court. Stoke Edith. Shucknall Farm. Bodenham Quarry, U.L., A.L. Ecknall Copse. Prior's Court. Shucknall Hill, A.L. Checkley Common. Woolhope, WP.L.

May Hill District . . Long Hope. Huntley Hill. May Hill. Rock, W.L.

Usk District . . . Usk, U.L. Llanfrechfa. Llanbadoc, A.L. Beech Hill. Cefn Ila, L.L., W.L.? Ty Newydd, W.L. Cilfigan.

Builth District . . . Aberedw, U.L., L.L. Blaenau. Cwm Craig ddu, U.L., A.L., L.L. Henllyn Hill. New Hall? Coryn, W.L.?

Llandilo District . . Pont ar y llechau. Effynant. Rhiw-goch. Coed y Sion, M.S. Golden Grove, 2 and 4. North of Trichrug.

Marloes District . . Marloes Bay, M.S. Wooltack Bay, M.S.

HYPOTHYRIS STRICKLANDI.

REF.—Murchison, Sil. Syst., t. 13, f. 19.

Malvern District . . Croft, W.L. East of Ledbury.

May Hill District . . Rock, W.L.

Usk District . . . Tucking Mill. Llanbadoc, A.L. Bryn Craig.

HYPOTHYRIS SPHÆRICA.

REF.—Murchison, Sil. Syst., t. 13, f. 17.

Malvern District . . Eastnor Castle, W.L.

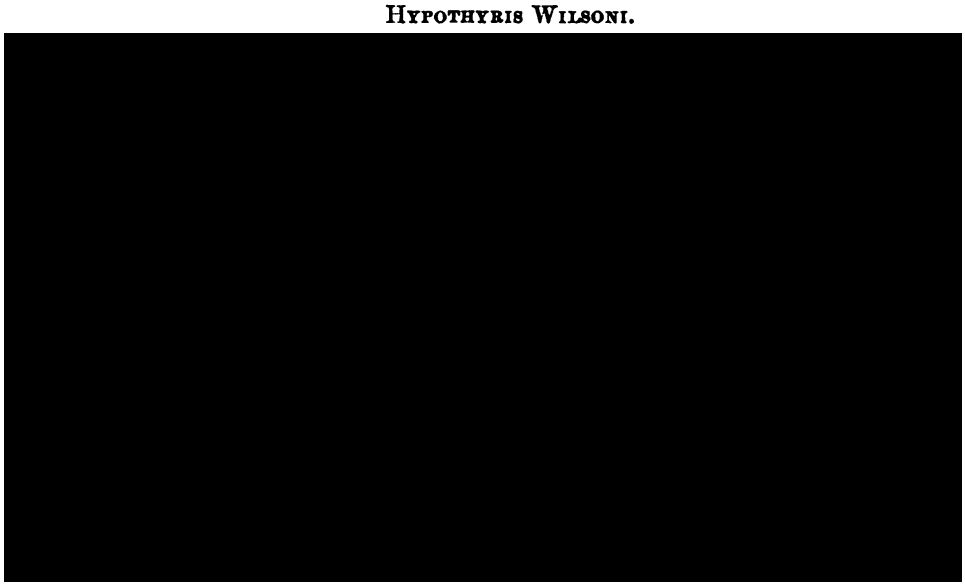
Woolhope District . . Littlehope, WP.L. Dormington Wood.

HYPOTHYRIS TRIPARTITA.

REF.—Murchison, Sil. Syst., t. 21, f. 15.

Llandilo District . . Goleugoed (Murchison).

HYPOTHYRIS WILSONI.



Builth District . . . New Hall, U.L. Cwm Craig ddu, L.L. Erw Gilfach.

Llandilo District . . Dafaddfa Uchaf, S. Pont ar y llechau, T. Effynant. Myddelton Park. Swansea Road, M.S., 6. Golden Grove, 2.

LEPTÆNA ANTIQUATA.

REF.—*Orthis*, Murchison, Sil. Syst., t. 13, f. 13.

Woolhope District . . Woolhope (Murchison). Dormington Wood.

LEPTÆNA COMPLANATA.

REF.—Murchison, Sil. Syst., t. 20, f. 6.

Malvern District . . Under Worcester Beacon, U.C.

LEPTÆNA DEPRESSA.

REF.—Murchison, Sil. Syst., t. 12, f. 2.

Malvern District . . Pound, U.L. W. of Rilbury, A.L. Near Brockhill, L.L. Under Hereford Beacon, W.L. Eastnor Castle, Ledbury. Dunbridge Wood. E. of Ledbury. Under Worcester Beacon, W.S. Storridge. Storridge, WP. L. Worcester Beacon. Worcester Beacon, U.C.

Abberley District . . Ridge Hill Farm, A.L. Hill End, W.L. Callow Farm, L.L. Martley Road, L.L. Walgrove Hill, A.L.

Woolhope District . . Parton, U.L. Hazle. Pilliard's Barn. Prior's Court. Shucknall Hill, A.L. Bodenham, A.L. North of Canwood, W.L. Dormington Wood. East of Canwood. Backbury Camp. Checkley Common, W.S.

May Hill District . . Rock. Huntley. South of Rock.

Tortworth District . . Pyrton Passage.

Usk District . . . Usk, U.L. Llanbadoc, A.L. Beech Hill. West of Russell's Farm, &c. Coed y Pan, L.L. Prescoed, &c., W.L. Bryn craig, W.S. Craig y Garcyd. Tucking Mill.

Builth District . . . Aberedw, A.L. Erw gilfach, W.L. Cwm craig ddu, A.L., W.S.

Llandilo District . . Rhiw goch. Pont ar y llechau. Coed y Sion, Llangadoc. Ty Newydd. Cefn Llwydlo. Mandinam. Goleugoed. Bwlch-Trebannau. Carreg gwynion. Grug. Bird's Hill. Golden Grove, M.S. Nelson's Tower Wood. Myddelton Hall.

Freshwater District . Freshwater East.

Marloes District . . Marloes Bay.

LEPTÆNA EUGLYPHA.

REF.—Murchison, Sil. Syst., t. 12, f. 1.

Malvern District . .	Chance's Pitch, U.L. Upper Mitchell, L.L. West of Rilbury, A.L. Near Brock Hill, L.L. South of Eastnor Castle. Ledbury, W.L. Under Hereford Beacon.
Abberley District . .	Hole Farm. Hill End, W.L. Callow Farm, W.L.
Woolhope District . .	Shucknall Hill, A L. Bodenham, A.L. Lindells, W.L. Dormington Wood. Backbury Camp.
May Hill District . .	West of Rock Farm.
Usk District . . .	Llangibby, A.L. Llanbadoc. Beech Hill. Russell's Farm. Coed y Pan, L.L. Cilfigan, W.L. Prescoed. Bryn Graig, W.S. Craig y Garcyd.
Builth District . . .	Aberedw.
Llandilo District . .	Swansea Road, 6. Golden Grove, 4. Goleugoed. Cefn-Rhyddan. Pen y lan. Effynant.

LEPTÆNA FUNICULATA.

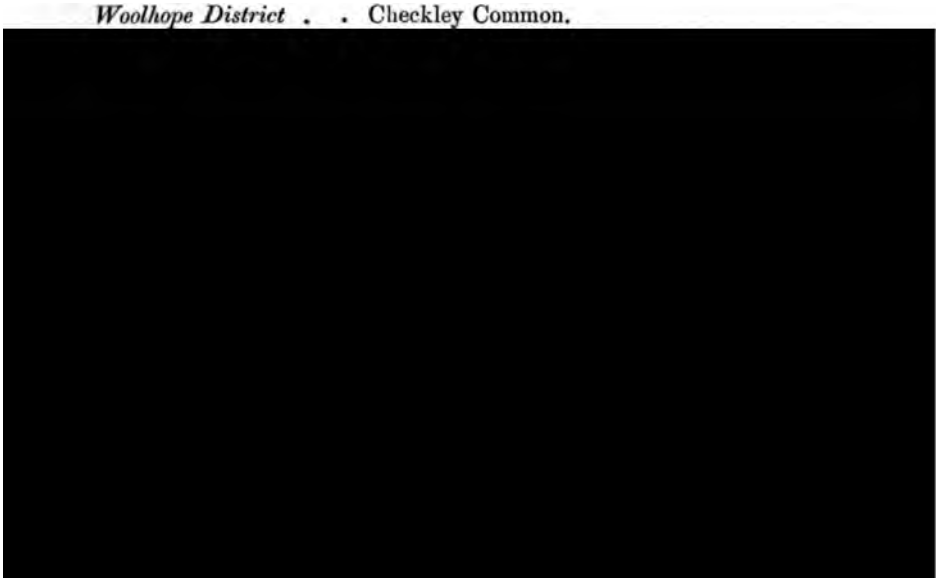
REF.—*Orthis funiculata*, M'Coy, Sil. Fossils of Ireland. Pl. 3, f. 11.

Malvern District . .	Storridge. Eastnor Castle.
Abberley District . .	Hill End, W.L. Collins' Green.
Woolhope District . .	East of Canwood.
Usk District . . .	Llangibby, A.L. Coed y Pan, L.L. Cilorgyr, W.L. Bryn Craig, W.S.
Llandilo District . .	Nelson's Tower Wood. Swansea Road, 6. Golden Grove, M. S. Effynant.

LEPTÆNA LEPISMA.

REF.—Murchison, Sil. Syst., t. 8, f. 7.

Malvern District . .	Hereford Beacon.
Woolhope District . .	Checkley Common.



LEPTÆNA MINIMA.

REF.—Murchison, Sil. Syst., t. 13, f. 4.

Woolhope District . . Wootton Farm. Checkley Common.

LEPTÆNA OBLONGA, Pand.

REF.—De Verneuil, Geol. Russia, &c., pl. 15, f. 2.

Haverfordwest District . Sholes Hook. Pelcombe Cross.

LEPTÆNA (CHONETES, Fisch.) SARCINULATA, Schloth.

REF.—*Leptæna lata*, Murchison, Sil. Syst, t. 3, f. 10 b, t. 5, f. 13.

Malvern District . . Overley, U.L. Brock Hill. Hales End. Mathon. Hope End. Pound. Coomb. Frith. Hall Court. West of Rilbury.

Abberley District . . Ankerdine Hill, U.L. Callow Farm (one or two), W.L. Barrell Hill. Walgrove Hole Farm. Hill End.

Woolhope District . . Putley. Pilliard's Barn. Hazle. Parton. Prior's Court. Wonder. Old Sutton. Backbury Camp. Welch Court, &c. Bodenham, U.L., A.L. Shucknall Hill, A.L. Ecknall, &c. Stoke Edith.

May Hill District . . S.W. of Hobbs. West of Rock Farm. North of Taynton. Long Hope.

Tortworth District . . Pyrton Passage.

Usk District . . . Usk, U.L. Llanfrechfa. Llangibby. Beech Hill, &c. Llangibby, A.L. Llanbadoc. Russell's Farm. Cefn Ila, L.L. Ysgubor Gwynt. Cilfigan, W.L. Bryn Craig, W.S. Tucking Mill. Craig y Garcyd.

Builth District . . . Blaenau, U.L. Henllyn. Pwll ddu. Cwm Craig ddu, U.L., L.L.

Llandilo District . . Storm Hill Lodge, T.S. Dafaddfa Uchaf. Allt ddu, M.S. Golden Grove, M.S. Nelson's Tower Wood. Gilfach. North of Trichrug. Llechclawdd. Goleugoed. Myddelton Hall.

LEPTÆNA SERICEA.

REF.—Murchison, Sil. Syst., t. 19, f. 1, 2, 2 a.

Malvern District . . Worcester Beacon, WP. L., W.S. Storridge, WP. L.

Woolhope District . . South of Woolhope, WP. L.

Builth District . . . Tyn y graig.

Llandilo District . . Bwlch-Trebannau. Carreg gwynion. Goleugoed. Blaendyffryn (inclosed in trap), L.S. Swansea Road, 4, 6. Golden Grove, 1. Llandilo, L.S. Myddelton Hall. Nant-Hirion. Llangwm.

LEPTÆNA SERICEA, *var.* SPINANGULA, Phill.

A convex var. with extended pointed ears.

Malvern District . . Brock Hill Section, L.L. Worcester Beacon, WP.L. Fair Oaks, U.C.

LEPTÆNA TENUISTRIATA.

REF.—Murchison, Sil. Syst., t. 22, f. 2 a.

Malvern District . . Worcester Beacon, WP.L. Wych, U.C.
May Hill District . . Huntley, U.C.
Tortworth District . . Woodford Green, U.C.
Llandilo District . . Nelson's Tower Wood, M.S. Myddelton Hall. Golden Grove, L.S. Grug. Bird's Hill.

LEPTÆNA TRANSVERSALIS.

REF.—Murchison, Sil. Syst., t. 13, f. 2.—Also *L. duplicata*, Sil. Syst., t. 22, f. 2, (inner cast).

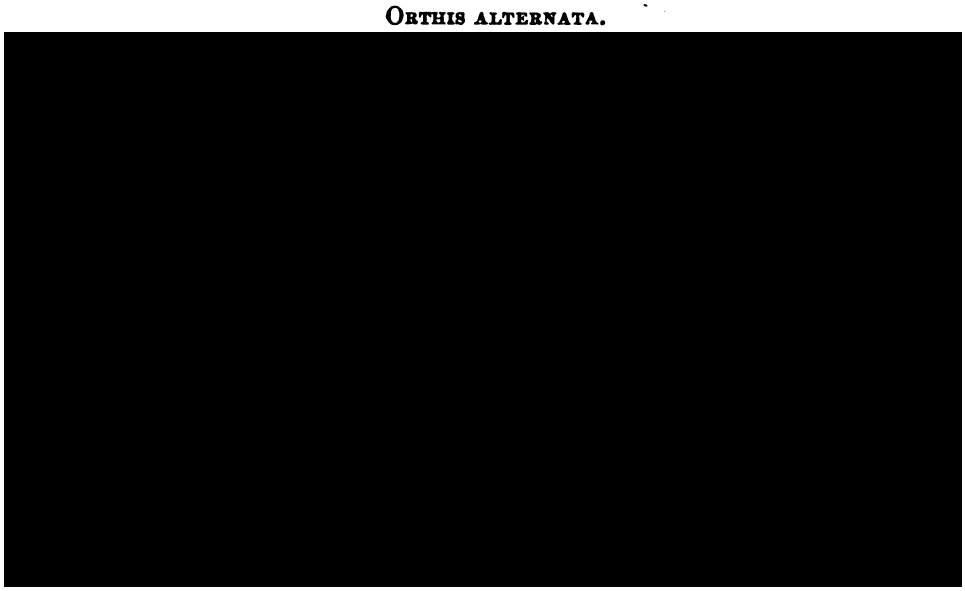
Malvern District . . Stumps Wood, W.S.
Abberley District . . Ridge Hill Farm, A.L. Abberley, W.L. Callow Farm. Martley Road, L.L.
Woolhope District . . North of Canwood, W.S. Checkley Common. N.E. of Pilliard's Barn. Little Hope. South of Woolhope. Dormington Wood.
Builth District . . . Wellfield.
Llandilo District . . Goleugoed. Cefn Llwydlo. Coed y Sion. Melin y cwm. Bird's Hill. Golden Grove, M.S.

ORTHIS ACTONIÆ.

REF.—Murchison, Sil. Syst., t. 20, f. 16.

Llandilo District . . Castell Craig Gwyddon. Goleugoed. Bird's Hill.
Haverfordwest District . Llandowror. Robeston Wathen.

ORTHIS ALTERNATA.



ORTHIS BILOBA, Linn.

REF.—*Spirif. sinuatus*, Murchison, Sil. Syst., t. 13, f. 10.

Malvern District . . Eastnor Castle. Storridge, WP. L.
Woolhope District . . Worcester Beacon, W.S. Dormington Wood.
Usk District . . . Bryn Graig. Craig y Garcyd.
Llandilo District . . Ty Newydd. Cefn Llwydlo. Cefn Rhyddan.
Haverfordwest District. Robeston Wathen, M.S. Moor near St. Clair's.

ORTHIS CALLIGRAMMA, Dalm.*

REF.—*O. virgata*, Murchison, Sil. Syst., t. 20, f.15, and *Spirifer plicatus*, Sil. Syst., t. 21, f.6.

Malvern District . . Worcester Beacon. Storridge. Gunwick Mill. Hereford Beacon.
May Hill District . . Huntley Hill. May Hill. South End of May Hill.
Tortworth District . . Long's Quarry.
Builth District . . . Tan y Graig. Pen Carreg.
Llandilo District . . Carreg Gwynion. Trallwyn. Mandinam. Goleugoed. Cefn Llwydlo. Dynevor Park. Bird's Hill. Grug. Taliaris?
Haverfordwest District. Great Cresswell. Shole's Hook. Lampeter Hill.

ORTHIS RUSTICA.

REF.—Murchison, Sil. Syst., t. 12, f. 9.

Abberley District . . Abberley. Callow Farm.
Woolhope District . . Dormington Wood.

ORTHIS COMPRESSA.

REF.—Murchison, Sil. Syst., t. 22, f. 12.

Llandilo District . . Golden Grove, 1. Cefn Llwydlo. Nant-Hirion. Bird's Hill.
Haverfordwest District. Lann Mill. Ciln Park.

ORTHIS COSTATA.

REF.—Murchison, Sil. Syst., t. 21, f. 11.

May Hill District . . Huntley.
Llandilo District . . West of Pentre-bach. Carngoch.
Haverfordwest District. Robeston Wathen.

ORTHIS ELEGANTULA, Dalm.

REF.—*O. canalis*, Murchison, Sil. Syst., t. 20, f. 8; t. 13, f. 12.

Malvern District . . Under Worcester Beacon. Worcester Beacon. Gunwick Mill. Eastnor Park. Storridge.
Abberley District . . Hill End, W.L. Walgrove, A.L. Hill End, L.L. Callow Farm, W.L. Collin's Green.

* Mr. Salter is of opinion that *O. virgata*, and *Spirifer plicatus*, Sil. Syst., are opposite valves of the same species.—See Palæontological Appendix.

Woolhope District . . North of Canwood. Dormington Wood. Lindels. Checkley Common. South of Woolhope. Shucknall Farm. Bodenham, U. L., A. L. Shucknall Hill, A.L. Backbury Camp, A.L. Wooton Farm. East of Canwood. Checkley Common. South of Dormington Wood. Woolhope, W.S.

May Hill District . . Rock Farm. South of Rock, W.S. May Hill, U.C. Huntley Hill.

Usk District . . . Llangibby, A. L., No. 11. Dowlas Farm, L.L. Cefn Ila. Ysgubor Gwynt. Ty Newydd, W.L. Trostra. Prescoed. Cilorgyr, &c.

Builth District . . . Tan y Graig. Cwm Craig ddu, A.L., L.L. Erw Gilfach.

Llandilo District . . Myddfai. Pwll Calch. Llangadoc. Coed y Sion. Cefn Llwydlo. Cefn Rhyddan. Llanfihangel Aberbythwych. Bwlch-Trebannau. Carreg Gwynion. Goleugoed. Golden Grove, 1, 2, 3, 4. Effynant. Myddelton Hall. Llangwm. Nant Hirion. Llandilo. Aberglasney. Llwych gwyn. Penllwynan. Grug. Pont brennareth. Swansea Road, 6.

Haverfordwest District. Robeston Wathen. Pant dwfn. Great Criswell, Llandowror. Lann Mill. Priory Mill. Shole's Hook. Crinow. Lampeter Velfrey.

Freshwater District . Freshwater East.

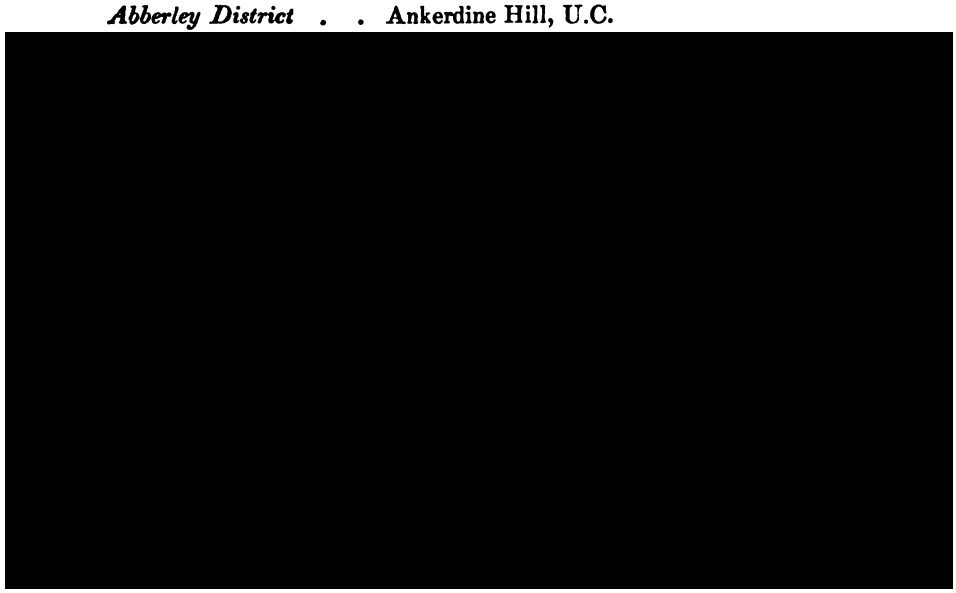
Marloes District . . Wooltack. Marloes Bay, E. 6, 3 a. Slate Mill. Hooton. St. Ishmael's. Lindsway.

ORTHIS EXPANSA.*

REF.—*O. expansa* and *O. pecten*, Murchison, Sil. Syst., t. 20, f. 14, and 21. f. 9.

Malvern District . . Worcester Beacon, U.C.

Abberley District . . Ankerdine Hill, U.C.



Abberley District . . Callow Farm.
Woolhope District . . Shucknall Hill. Bodenham.
Usk District . . . Llangibby, U.L. Usk. Darren. Llanbadoc, A.L. Beech Hill. Russell's Farm. South of Radyr. Llangibby. Coed y Pan, L.L. Dowlas Farm. Ty Newydd, W.L. Craig y Garcyd, W.S.
Builth District . . . Cwm Craig ddu. Erw Gilfach.
Llandilo District . . Myddfai. Near Coed Sion, M.S. Llangadoc. Swansea Road, 4. Myddelton Hall. Golden Grove.
Haverfordwest District. Ciln Park.
Malvern District . . Slate Mill. Lindsway.

ORTHIS FLABELLULUM.

REF.—Murchison, Sil. Syst., t. 21, f. 8. Palæont. Appendix.

Malvern District . . Worcester Beacon.
Llandilo District . . Goleugoed. Bird's Hill Quarry.
Haverfordwest District. Crinow. South of Narberth. Robeston Wathen. Fron Veynor fach.

ORTHIS GRANDIS.

REF.—Murchison, Sil. Syst., t. 20, f. 12, 13.

Haverfordwest District. Lann Mill.

ORTHIS HYBRIDA.

REF.—Murchison, Sil. Syst., t. 13, f. 11.

Malvern District . . Brock Hill, L.L. Under Worcester Beacon, W.S. Dog Hill, WP.L. Eastnor Castle. Bason Court Farm, A.L.
Abberley District . . Callow Farm, W.L. Collin's Green. Hole Farm, L.L.
Woolhope District . . North of Canwood. East of Canwood. Dormington Wood. Lindels. Shucknall Hill, L.L.
May Hill District . . Rock. South of Rock Farm, W.S.
Usk District . . . Ysgubor Gwynt. Trostra. Ty Newydd. Prescoed. Cilorgyr, &c.

ORTHIS INFLATA, Salter.

REF.—Palæontological Appendix.

Builth District . . . Tan y Graig.
Llandilo District . . Bird's Hill. Myddelton Hall.

ORTHIS INSULARIS, Eichwald.

REF.—Murchison, Geol. Russia, t. 8, f. 7.

Llandilo District . . Castell Craig Gwyddon. Mandinam. Goleugoed.

ORTHIS LATA.

REF.—*O. lata*, Murchison, Sil. Syst., t, 22, f. 10, and *O. protensa*, Sil. Syst., t. 22, f. 8, 9, (one species, according to Mr. Salter).

Llandilo District . . Goleugoed. Llandilo.
Haverfordwest District. Llandowror Lane. Robeston Wathen.
Marloes District . . Marloes Bay, E. Slate Mill.

ORTHIS LUNATA.

REF.—Murchison, Sil. Syst., t. 5, f. 15.

Malvern District . . Upper Mitchel. East of Ledbury.
Abberley District . . Barrell Hill, U. L. Wallgrove, U. L. Hill End, U.L.
Woolhope District . . Hazle. Ecknall Copse. Welsh Court.
May Hill District . . Longhope.
Usk District . . . Llangibby, U.L. Cefn Ila. Ysgubor Gwynt.
Builth District . . . Cwm Craig ddu, U.L.
Llandilo District . . Pont ar y llechau, T., M.S.

ORTHIS ORBICULARIS.

REF.—Murchison, Sil. Syst., t. 5, f. 16.

Malvern District . . Hale's End. Mathon. Hope End. Awkbridge Farm. Pound. Hall Court. West of Rilbury. Eastnor Castle.
Abberley District . . Ridge Hill, A.L.
Woolhope District . . Putley. Hazle. Perton. Welsh Court. Backbury Camp, A.L. Ecknall Copse. Shucknall Farm. Prior's Court. Bodenham, A.L. Lindels.
Usk District . . Usk. Llanbadoc. Beech Hill. West of Darren, U.L. Darren, A.L. Coed y Pan.
Builth District . . . Blaenau. Aberedw, U.L., A.L. Henllyn. Pwll ddu.
Llandilo District . . East of Trichrug. Dafaddfa Uchaf, South. Middleton Hall. Cnwc.

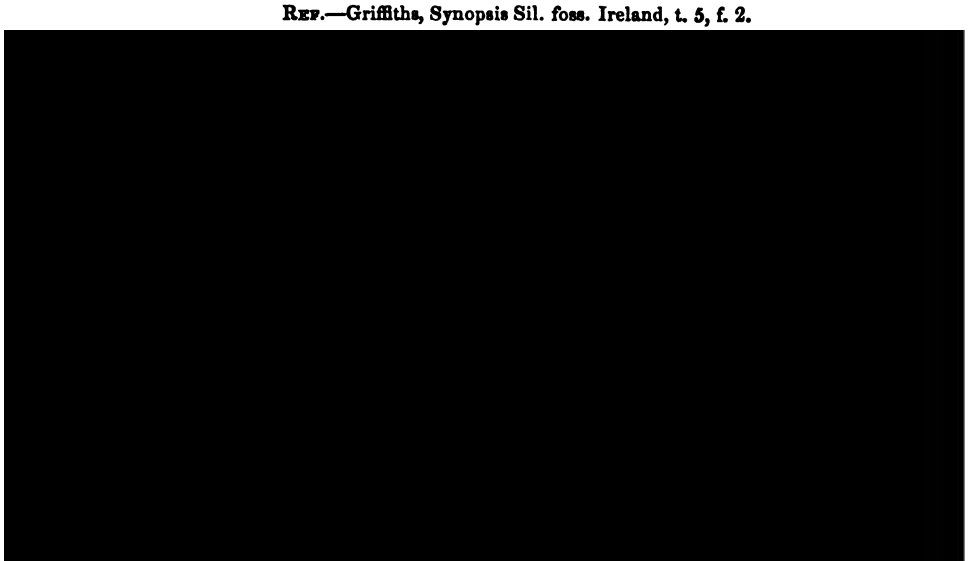
ORTHIS RADIANS.

REF.—Murchison, Sil. Syst., t. 22, f. 11.

Llandilo District . . Bird's Hill Quarry.

ORTHIS REVERSA, Salter.

REF.—Griffiths, Synopsis Sil. foss. Ireland, t. 5, f. 2.



ORTHIS TESTUDINARIA, var.

REF.—Palæontological Appendix.

Builth District . . . Llanelwedd.
Llandilo District . . Cefn Llwydlo. Aberglasney. Llwych gwyn.
Haverfordwest District. Panblewin. Lann Mill. Pant dwfn.

ORTHIS VESPERTILIO (including *bilobata*).

REF.—Murchison, Sil. Syst., t. 20, f. 11.

Malvern District . . Obelisk. Worcester Beacon, U.C.
May Hill District . . S.E. of May Hill.
Llandilo District . . Carreg Gwynion. Cefn Llwydlo. Goleugoed. Llandilo. Bird's Hill Green. Golden Grove, 1. Drwsllwyn. Nant Hirion. Grug. Llangwm.
Haverfordwest District. Lann Mill. Priory Mill. Crinow. Ciln Park. Panblewin. Robeston Wathen. Pant dwfn.

ORTHIS CORRUGATA, Portlock.

REF.—Geol. Report on Tyrone, t. 32, f. 17.

Usk District . . . Craig y Garcyd.
Builth District . . . Cwm Craig ddu.
Llandilo District . . Golden Grove.

ORTHIS LIRATA.

REF.—*Spirifer? liratus*, Murchison, Sil. Syst., t. 22, f. 6.

Marloes District . . Marloes Mill, M.S. Marloes Bay.

ORTHIS ALATA.

REF.—*Spirifer? alatus*, Murchison, Sil. Syst., t. 22, f. 7.

Caermarthen District . Pensarn. Mount Pleasant.

ORTHIS LÆVIS.

REF.—*Spirifer? lævis*, Murchison, Sil. Syst, t. 21, f. 12.

Malvern District . . Gullet Wood, U.C.
May Hill District . . May Hill, U.C.
Llandilo District . . Noeth Grûg.

PENTAMERUS GALEATUS.

REF.—*Atrypa*, Dalman, Murchison, Sil. Syst., t. 8, f. 10.

Malvern District . . West of Rilbury, A.L. Brock Hill Section, L.L. Storridge, W.L. Ledbury. Eastnor Park. Eastnor Castle. Dunbridge Wood. East of Ledbury. Brock Hill Section, W.S.
Abberley District . . Hill End, W.L. Hill End, L.L. Callow Farm, W.L.
Woolhope District . . East of Canwood, W.L. Checkley Common, W.S. Dormington Wood. Lindels.
May Hill District . . South of the Rock.
Usk District . . . Llanbadoc, A.L. Beech Hill, A.L. Ty Newydd.

Builth District . . . Aberedw, A.L.
Llandilo District . . Swansea Road, 8, M.S. Golden Grove, 4.

PENTAMERUS KNIGHTII.

REF.—Murchison, Sil. Syst., t. 6, f. 8.

Abberley District . . Ridge Hill Farm, A.L.
Woolhope District . . Bodenham, A.L.

PENTAMERUS LÆVIS.

REF.—Murchison, Sil. Syst., t. 19, f. 9.

Malvern District . . Gunwick Mill, U.C. Fair Oaks. Howler's Heath.
Abberley District . . Ankerdine Hill.
May Hill District . . May Hill, S.E.
Builth District . . . Pen Cerrig.
Llandilo District . . Pen y lan. Mandinam.
Haverfordwest District. Rosemarket.

PENTAMERUS OBLONGUS.

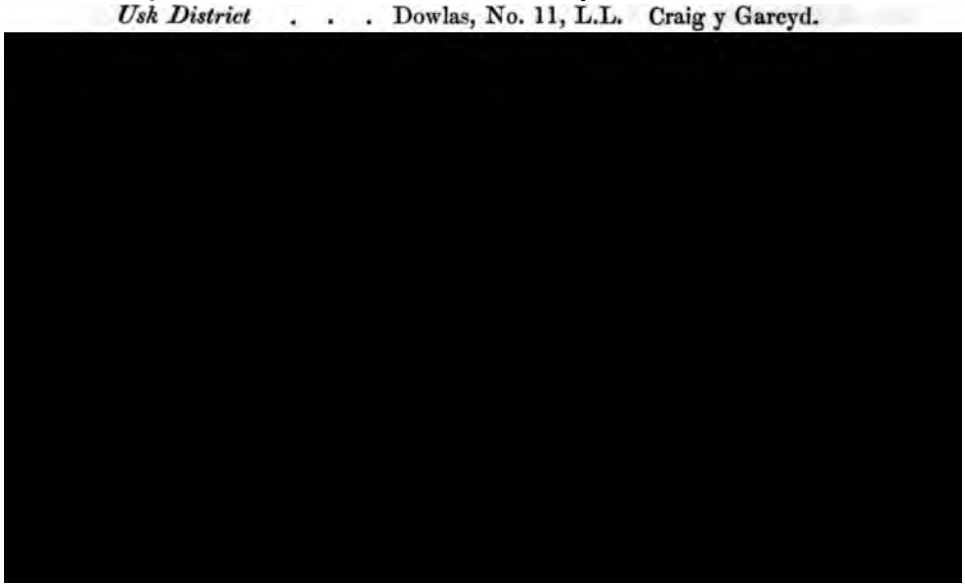
REF.—Murchison, Sil. Syst., t. 19, f. 10.

Malvern District . . Fair Oaks, U.C.
May Hill District . . Huntley.
Llandilo District . . Castell Craig Gwyddon.

SPIRIFERA CRISPA.

REF.—Murchison, Sil. Syst., t. 12, f. 8.

Malvern District . . South of Eastnor Castle, L.L. East of Ledbury, W.L. Under Worcester Beacon, WP.L.
Abberley District . . Ankerdine Hill, U.C. Hole Farm, L.L. Ridge Hill Farm, A.L. Abberley, W.L. Callow Farm.
Woolhope District . . Dormington Wood, W.L. North of Canwood. Lindels' Green. South of Dormington Wood?
May Hill District . . Rock, W.L. May Hill. South of Rock.
Usk District . . . Dowlas, No. 11, L.L. Craig y Garcyd.



Usk District . . . Llanbadoc, A.L. Russell's Farm, A.L.
Llandilo District . . Ty Newydd. Nelson's Tower Wood, M.S. Myddelton Hall. Golden Grove, 4. Coed Sion. Rhiw goch, M.S. Llanfihangel Aberbythwych.
Haverfordwest District. Shole's Hook, L.S.
Marloes District . . Wooltack, M.S. Marloes Bay.

SPIRIFERA INTERLINEATA.

REF.—Murchison, Sil. Syst., t. 6, f. 6.

Malvern District . . Winning's Farm.
Abberley District . . Hole Farm, L.L.
Woolhope District . . Checkley Common, W.S.
Usk District . . . Craig y Garcyd.
Llandilo District . . Nelson's Tower Wood, M.S.

SPIRIFERA BIFORATA, Schloth.

REF.—Murchison, Geol. Russia, t. 3, f. 3.

Llandilo District . . Cefn Rhyddan. Cefn Llwydlo. Bird's Hill Green.

SPIRIFERA OCTOPLICATA.

REF.—Murchison, Sil. Syst., t. 12, f.7.

Malvern District . . Frith, U.L. Hereford Beacon, W.L.
Abberley District . . Hole Farm, L.L. Abberley. Callow Farm.
Woolhope District . . North of Canwood, W.L. N.E. of Pilliard's Barn. Bodenham, A.L. Dormington Wood. Lindels' Green.
May Hill District . . May Hill. Huntley Hill. South of Rock.
Usk District . . . Usk. Beech Hill, A.L. Llancayo. West of Darran, A.L. Russell's Farm, A.L. Coed y Pan. Cefn Ila, L.L. Dowlas, L.L. Ty Newydd. Cilorgyr. Bryn Craig.
Builth District . . . Cwm Craig ddu, L.L., W.S. Erw Gilfach.
Llandilo District . . Ty Newydd. Pont ar y llechau. Golden Grove, T., M.S. Dafaddfa Uchaf, South, U.S. Myddelton Hall, M.S.
Haverfordwest District. Crinow, M.S.
Freshwater District. . Freshwater East.
Marloes District . . Wooltack. Marloes Bay.

SPIRIFERA PISUM.

REF.—Murchison, Sil. Syst., t. 13, f. 9.

Malvern District . . Under Worcester Beacon, WP. L.
Woolhope District . . Dormington. Lindels.

SPIRIFERA PTYCHODES.

REF.—Murchison, Sil. Syst., t. 3, f. 13.

Malvern District . . Pound, U.L. Upper Mitchel. Brock Hill Section, L.L.

Abberley District . . Ankerdine Hill, A.L.
Woolhope District . . Bodenham, A.L.
Usk District . . . Llanbadoc, A.L.
Llandilo District . . Dafaddfa Uchaf, South, U.S.
Freshwater District . . Newton.
Marloes District . . Slate Mill. St. Ishmael's.

SPIRIFERA TRAPEZOIDALIS.

REF.—Murchison, Sil. Syst., t. 5, f. 14.

Malvern District . . Storridge, WP. L. Under Worcester Beacon.
Abberley District . . Abberley? W.L.
Usk District . . . Craig y Garcyd.
Llandilo District . . Golden Grove, M.S.

TABLE XV.—*Geographical Distribution of Brachiopoda.*

NAMES OF SPECIES.	Western Districts.						Eastern Districts.						No. of Occurrences of each Species.	No. of Districts in which each Species occurs.
	Marloes.	Freshwater.	Haverfordwest.	Caermarthen.	Llandilo.	Builth.	Usk.	Tortworth.	May Hill.	Woolhope.	Abberley.	Malvern.		
Lingula attenuata	.	.	.	.	.	1	.	.	.	.	1	4	6	3
—— cornea	.	.	.	.	.	.	.	.	.	1	1	.	2	2
—— crumena	.	.	.	.	.	.	.	.	.	.	.	1	1	1
—— granulata	.	.	2	.	3	.	.	.	.	.	.	.	5	2
—— lata?	.	.	.	.	.	.	.	.	.	.	1	.	1	1
—— Lewisii	.	1	.	.	1	.	3	.	.	4	2	1	12	6
—— minima	.	.	.	.	.	.	.	.	.	.	.	1	1	1
—— parallela	.	.	.	.	.	.	.	.	.	.	.	1	1	1
Orbicula punctata	1	.	.	.	.	.	.	.	.	.	.	.	1	1
—— rugata	.	.	.	.	.	2	3	1	1	8	5	6	26	7
—— corrugata	.	.	.	.	.	.	.	.	.	1	.	.	1	1
—— striata	.	.	.	.	.	2	.	.	.	.	.	.	2	1
—— Forbesii	.	.	.	.	.	.	.	.	.	1	.	.	1	1
Atrypa crassa	.	.	.	.	6	.	.	.	.	.	.	.	6	1
—— depressa	.	.	.	.	1	.	.	.	.	.	.	2	3	2
—— didyma	.	.	.	.	5	1	5	.	.	2	1	.	14	5
—— globosa	1	.	.	.	5	.	.	.	.	.	.	1	7	3
—— hemisphærica	1	.	1	.	.	.	.	.	2	.	1	2	7	5

TABLE XV.—*Geographical Distribution of Brachiopoda*—continued.

NAMES OF SPECIES.	Western Districts.						Eastern Districts.						No. of Occurrences of each Species.	No. of Districts in which each Species occurs
	Marloes.	Freshwater.	Haverfordwest.	Carmarthen.	Llandilo.	Builth.	Usk.	Tortworth.	May Hill.	Woolhope.	Abberley.	Malvern.		
Leptæna antiquata	.	.	.	.	.	.	.	.	.	2	.	.	2	2
—— oblonga	.	.	3	.	.	.	.	.	.	.	.	.	3	.
—— complanata	.	.	.	.	.	.	.	.	.	.	.	1	1	1
—— depressa	.	.	.	.	15	3	9	1	3	11	5	13	62	10
—— euglypha	.	.	.	.	6	1	9	.	1	5	3	7	32	7
—— funiculata	.	.	.	.	4	.	4	.	.	1	2	2	13	5
—— lepisma	.	.	.	.	2	2	2	.	.	1	.	1	8	5
—— var. minor	.	.	.	.	2	3	3	.	.	.	.	.	8	3
—— lævigata	.	.	.	.	.	.	.	.	.	.	1	.	1	1
—— minima	.	.	.	.	.	.	.	.	.	2	.	.	2	2
—— sarcinulata	.	.	.	.	10	4	13	1	4	13	5	10	60	8
—— sericea	.	.	.	.	10	1	.	.	.	1	.	2	14	4
—— tenuistriata	.	.	.	.	4	.	.	1	1	.	.	1	7	4
—— transversalis	.	.	.	.	8	1	.	.	.	6	4	1	20	5
Orthis Actonia	.	.	1	.	3	.	.	.	.	.	.	.	4	2
—— alternata	.	.	2	.	1	.	.	1	.	.	.	1	5	4
—— applanata	.	.	.	.	.	.	1	.	.	.	.	.	1	1
—— biloba	.	.	2	.	3	.	2	.	.	2	.	2	11	5
—— calligramma	.	.	3	.	9	2	.	1	3	.	.	2	20	6
—— rustica	.	.	.	.	.	.	.	.	.	1	1	.	2	2
—— compressa	.	.	2	.	4	.	.	.	.	.	.	.	6	2
—— costata	.	.	1	.	2	.	.	.	1	.	.	.	4	4
—— elegantula	6	1	9	.	25	3	8	.	4	14	6	6	82	10
—— pecten	1	.	.	.	1	.	.	.	.	2	.	.	4	3
—— expansa	.	.	.	.	6	1	.	.	3	2	1	1	14	6
—— filosa	2	.	1	.	6	2	12	.	.	2	1	7	33	8
—— flabellulum	.	.	4	.	2	.	.	.	.	.	.	1	7	3
—— grandis	.	.	1	.	.	.	.	.	.	.	.	.	1	1
—— hybrida	.	.	.	.	.	.	5	.	2	5	3	5	20	5
—— inflata	.	.	.	.	2	1	.	.	.	.	.	.	3	2
—— insularis	.	.	.	.	3	.	.	.	.	.	.	.	3	1
—— lata	2	.	2	.	2	.	.	.	.	.	.	.	6	3
—— lunata	.	.	.	.	1	1	3	.	1	3	3	2	14	7
—— orbicularis	.	.	.	.	4	4	6	.	.	19	1	8	42	6
—— radians	.	.	.	.	1	.	.	.	.	.	.	.	1	1
—— reversa	.	.	.	.	3	.	1	.	.	.	.	.	4	2
—— semicircularis	1	.	.	.	.	.	.	.	.	.	.	1	2	2
—— testudinaria	.	.	3	.	2	2	.	.	.	.	.	2	4	4
—— var.	.	.	3	.	3	1	.	.	.	.	.	.	7	3
—— vespertilio	.	.	7	.	10	.	.	.	1	.	.	2	20	4
—— corrugata	.	.	.	.	1	1	1	.	.	.	.	.	3	3
Pentamerus galeatus	.	.	.	.	2	1	3	.	1	4	3	9	23	7
—— Knightii	.	.	.	.	.	.	.	.	.	1	1	.	2	2
—— lævis	.	.	1	.	2	1	.	.	1	.	1	3	9	6
—— oblongus	.	.	.	.	1	.	.	.	1	.	.	1	3	3
Spirifera crispa	1	1	.	.	.	.	2	.	3	4	5	3	19	7
—— cyrtæna	2	.	1	.	8	.	2	.	3	6	2	4	28	8
—— interlineata	.	.	.	.	1	.	1	.	.	1	1	.	4	4
—— biforata	.	.	3	.	1	.	.	.	.	.	.	.	4	2
—— octoplicata	2	.	1	.	5	2	11	.	3	5	3	2	34	9
—— pisum	.	.	.	.	.	.	.	.	.	2	.	1	3	2
—— ptychodes	.	.	.	.	1	.	1	.	.	1	1	4	8	5
—— trapezoidalis	.	.	.	.	1	.	1	.	.	.	1	2	5	4
—— (Orthis)? lirata	1	.	.	.	.	.	.	.	.	.	.	.	1	1
—— alata	.	.	.	1	.	.	.	.	.	.	.	.	1	1
—— lævis	.	.	.	.	1	.	.	.	1	.	.	1	3	3
No. of Occurrences in each District	31	6	57	1	256	60	172	8	67	199	101	210	.	.
No. of Species in each District	19	6	24	1	61	28	34	8	32	51	40	63	.	.

Number of Species admitted 97. West 76 80 East.

Number of Occurrences admitted 1166. West 413 753 East.

The Brachiopoda, the most numerous of all the classes of organized fossils in the Lower Palæozoic strata, appear by the above table to be, also, the most equally distributed. This is the result, whether we regard the number of species, or the number of their occurrences. We might perhaps have expected this. The living groups of Brachiopoda appear (*Terebratulæ* in particular), though not abundantly, in the seas of various climates and at various depths, from the shallow water of the north-east coast of New Holland (observed by Mr. Jukes) to the coral depths of the Mediterranean (*Terebratula vitrea*), and the more profound channels of Zetland (*Tereb. psittacea*). Nor does there appear in the relation of Brachiopoda to peculiar qualities of water, or particular kind of sea bed, any *general law*, which might restrict within narrow limits their range of geographical distribution. The argillaceous, arenaceous, and calcareous deposits of the Palæozoic æra, are in no situation *totally* devoid of some traces of Brachiopod life, until we reach the very lowest masses, in which perhaps all marks of ancient organization* disappear.

Though upon the whole the eastern regions have the advantage—slightly in respect of species, greatly in respect of occurrences—the single district of Llandilo preserves that high place which has been conceded to it in other classes of fossils. It stands first in number of occurrences, and only a little second in number of species. The superiority of the eastern regions as a whole, may fairly be ascribed to the greater variety of physical conditions prevalent therein. The most abundant of the genus Lingula, and the most widely diffused is *L. Lewisii;* of Orbicula, *O. rugata;* of Atrypa, *A. reticularis;* of Hypothyris, *H. Wilsoni*, and *H. borealis;* of Leptæna, *L. depressa*, and *L. lata;* of Orthis, *O. elegantula;* of Pentamerus, *P. galeatus;* of Spirifera, *S. octoplicata.* To each of these an asterisk is affixed, and for *Atrypa reticularis*, undoubtedly the most widely distributed, and probably the

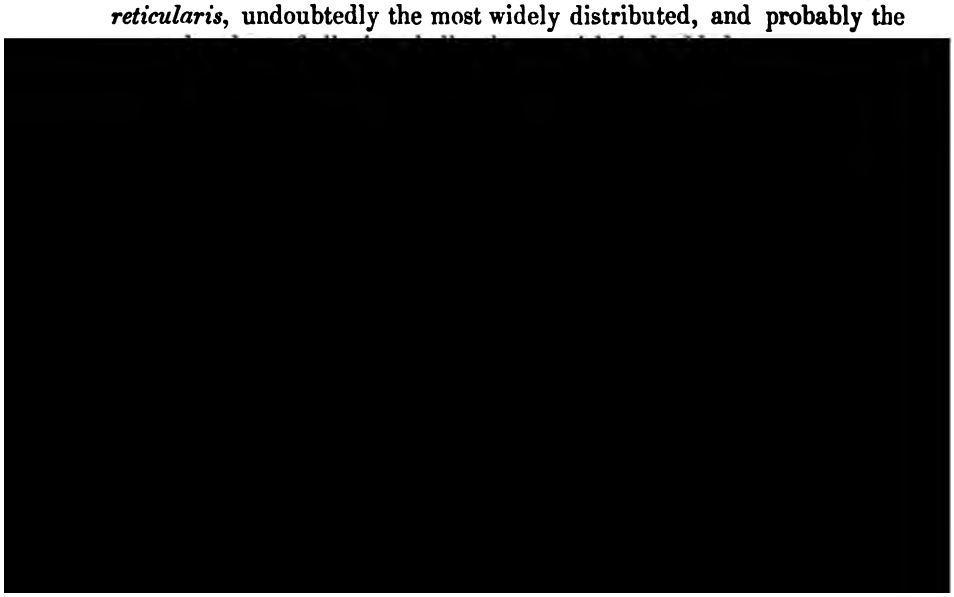


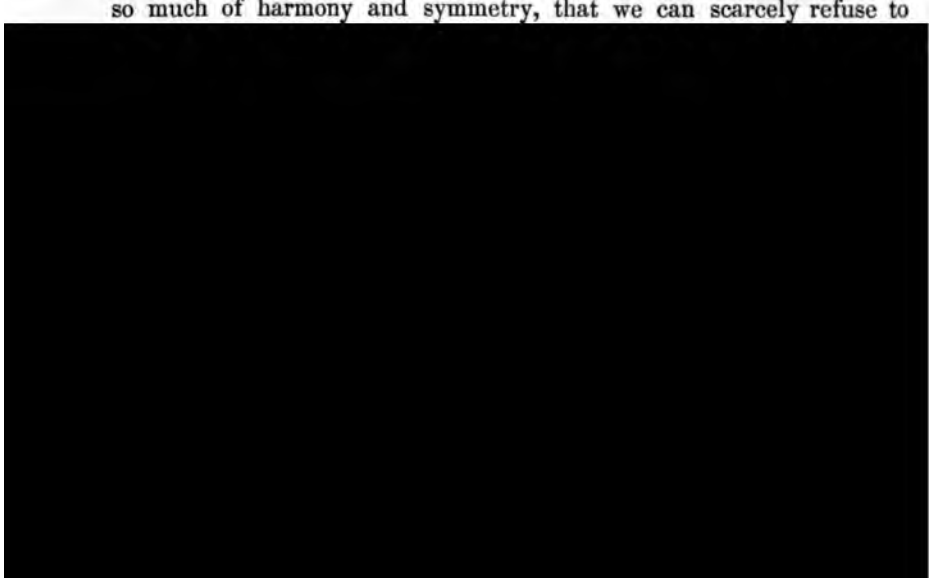
TABLE XVI.—*Geological Distribution of Brachiopoda in the Eastern Region.*

NAMES OF SPECIES.	STRATA IN DESCENDING ORDER.												No. of Occurrences of each Species.	No. of Strata in which each Species occurs.
	Downton Sandstone.	Upper Ludlow.	Aymestry Rock.	Lower Ludlow.	Wenlock Limestone.	Wenlock Shale.	Woolhope Limestone.	Upper Caradoc.	Lower Caradoc.	Trap.	Black Shale.	Lower Sandstone.		
Lingula attenuata	·	·	·	·	·	·	·	*	*	·	·	·	5	2
—— cornea	·	*	·	·	·	·	·	·	·	·	·	·	2	1
—— crumena	·	·	·	·	·	·	·	*	·	·	·	·	1	1
—— lata	·	·	·	·	*	·	·	·	·	·	·	·	1	1
—— Lewisii	·	·	*	*	*	*	·	·	·	·	·	·	10	4
—— minima	*	·	·	·	·	·	·	·	·	·	·	·	1	1
—— parallela	·	·	·	·	·	·	·	*	·	·	·	·	1	1
Orbicula rugata	·	*	*	·	·	·	·	·	·	·	·	·	24	2
—— corrugata	·	·	·	·	*	·	·	·	·	·	·	·	1	1
—— Forbesii	·	*	·	·	·	·	·	·	·	·	·	·	1	1
Atrypa depressa	·	·	·	·	·	·	*	·	·	·	·	·	2	1
—— didyma	·	*	*	*	·	·	·	·	·	·	·	·	8	3
—— globosa	·	·	·	·	·	·	·	*	·	·	·	·	1	1
—— hemisphærica	·	·	·	·	·	·	·	*	·	·	·	·	5	1
—— lens	·	·	·	·	·	·	·	*	·	·	·	·	8	1
—— linguifera	·	·	·	·	*	*	*	·	·	·	·	·	7	3
—— obovata	·	·	·	*	·	·	·	·	·	·	·	·	3	1
—— reticularis	·	*	*	*	*	*	*	*	·	·	·	·	68	7
—— var. orbicularis	·	·	·	·	·	·	·	*	·	·	·	·	8	1
—— rotunda	·	·	·	·	*	·	·	·	·	·	·	·	1	1
—— tumida	·	·	*	*	*	*	·	·	·	·	·	·	21	4
—— undata	·	·	·	·	·	·	·	*	·	·	·	·	3	1
Hypothyris bidentata	·	·	·	·	*	*	·	·	·	·	·	·	4	2
—— borealis	·	*	*	·	*	·	·	·	·	·	·	·	20	3
—— brevirostris	·	·	·	·	·	*	·	·	·	·	·	·	2	1
—— crispata	·	·	·	·	*	·	·	·	·	·	·	·	3	2
—— cuneata	·	·	·	·	*	·	*	·	·	·	·	·	4	1
—— decemplicata	·	·	·	·	·	·	·	*	*	·	·	·	6	3
—— deflexa	·	·	·	·	*	*	·	·	·	·	·	·	5	2
—— furcata	·	·	·	·	·	·	·	*	*	·	·	·	5	2
—— interplicata	·	·	·	·	·	·	*	·	·	·	·	·	1	1
—— marginalis	·	·	·	·	*	*	*	·	·	·	·	·	6	3
—— navicula	·	*	*	*	·	·	·	·	·	·	·	·	13	3
—— nucula	·	*	*	·	*	·	·	·	·	·	·	·	24	3
—— pulchra	·	*	·	·	·	·	·	·	·	·	·	·	1	1
—— semisulcata	·	*	*	*	*	·	*	·	·	·	·	·	24	5
—— Stricklandi	·	·	*	·	*	*	·	·	·	·	·	·	7	3
—— sphærica	·	·	·	·	*	·	*	·	·	·	·	·	3	2
—— Wilsoni	·	*	*	*	*	*	·	·	·	·	·	·	28	5
Leptæna antiquata	·	·	·	·	·	·	·	·	·	·	·	·	2	1
—— complanata	·	·	·	·	·	·	·	*	·	·	·	·	1	1
—— depressa	·	*	*	*	*	*	*	*	·	·	·	·	42	7
—— euglypha	·	*	*	*	*	*	·	·	·	·	·	·	25	5
—— funiculata	·	·	*	*	*	*	·	·	·	·	·	·	9	4
—— lepisma	·	·	·	*	·	*	·	·	·	·	·	·	4	3
—— var. minor	·	·	·	*	*	·	*	·	·	·	·	·	3	3
—— lævigata	·	·	·	·	·	*	·	·	·	·	·	·	1	1
—— minima	·	·	·	·	·	*	*	·	·	·	·	·	2	2
—— sarcinulata	·	*	*	*	*	*	*	·	·	·	·	·	46	5
—— sericea	·	·	·	·	·	·	*	*	·	·	·	·	3	4
—— tenuistriata	·	·	·	·	·	·	·	*	·	·	·	·	3	2
—— transversalis	·	·	·	*	*	*	*	·	·	·	·	·	11	4
Orthis alternata	·	·	·	·	·	·	·	*	·	·	·	·	2	1
—— applanata	·	·	·	·	·	·	*	·	·	·	·	·	1	1
—— biloba	·	·	·	·	·	*	*	·	·	·	·	·	6	3
—— calligramma	·	·	·	·	·	·	·	*	·	·	·	·	6	1
—— costata	·	·	·	·	·	·	·	*	·	·	·	·	1	1
—— elegantula	·	·	*	*	*	*	*	*	·	·	·	·	38	6
—— expansa	·	*	·	·	*	*	·	*	·	·	·	·	8	3
—— filosa	·	*	*	*	*	*	·	·	·	·	·	·	22	5
—— flabellulum	·	·	·	·	·	·	·	*	·	·	·	·	1	1
—— hybrida	·	·	*	*	*	*	·	·	·	·	·	·	20	5
—— lunata	·	*	·	*	·	·	·	·	·	·	·	·	12	2
—— orbicularis	·	*	*	*	·	·	·	·	·	·	·	·	34	4
—— reversa	·	·	*	·	·	·	·	·	·	·	·	·	1	1

TABLE XVI.—*Geological Distribution of Brachiopoda, &c.*—continued.

NAMES OF SPECIES.	STRATA IN DESCENDING ORDER.												No. of Occurrences of each Species.	No. of Strata in which each Species occurs.
	Downton Sandstone.	Upper Ludlow.	Aymestry Rock.	Lower Ludlow.	Wenlock Limestone.	Wenlock Shale.	Woolhope Limestone.	Upper Caradoc.	Lower Caradoc.	Trip.	Black Shale.	Lower Sandstone.		
Orthis rustica	.	.	.	.	*	.	.	.	.	.	.	.	2	1
—— semicircularis	.	.	.	.	.	.	.	*	.	.	.	.	1	1
—— testudinaria	.	.	.	.	.	.	.	*	.	.	.	.	2	1
—— vespertilio	.	.	.	.	.	.	.	*	.	.	.	.	3	1
—— corrugata	.	.	.	.	.	*	.	.	.	.	.	.	1	1
Pentamerus galeatus	.	.	*	*	*	*	*	.	.	.	.	.	20	4
—— Knightii	.	.	*	.	.	.	.	.	.	.	.	.	2	1
—— lævis	.	.	.	.	.	.	.	*	.	.	.	.	5	1
—— oblongus	.	.	.	.	.	.	.	*	.	.	.	.	2	1
Spirifera crispa	.	.	*	*	*	*	*	.	.	.	.	.	17	5
—— cyrtæna	.	.	.	*	*	*	*	*	.	.	.	.	17	5
—— interlineata	.	.	.	*	*	*	.	.	.	.	.	.	3	3
—— octoplicata	.	.	*	*	*	*	.	.	.	.	.	.	24	5
—— pisum	.	.	.	.	.	.	*	.	.	.	.	.	3	1
—— ptychodes	.	.	*	*	.	.	.	*?	.	.	.	.	7	4
—— trapezoidalis	.	.	.	.	*	*	*	.	.	.	.	.	4	3
—— lævis	.	.	.	.	.	.	.	*	.	.	.	.	2	1
No. of Species in each Stratum	1	20	28	27	38	32	20	29?	3	.	.	.	.	.
	In Upper Silurian, 57 species.							In Lower Silurian, 29 species.						

In the distribution of Brachiopoda through the strata of the Eastern region, we remark, as in previous examples of other classes, from the first manifestations of this life (in the Lower Caradoc) an increase in the number of specific forms, as we ascend in the series of deposits, till in the Wenlock formation the maximum is reached. From this point the number of specific forms diminishes, and is reduced almost to 0 before we quit the uppermost Silurian zone. There is in this series of life so much of regularity, and, when different classes are compared, so much of harmony and symmetry, that we can scarcely refuse to



But though few examples can be substantiated of Brachiopodous shells which are confined to one set of strata having a wide geographical range, there still appears reason to conclude that *Lingula Lewisii*, *Orbicula rugata*, *Atrypa tumida*, *Hypothyris Wilsoni*, *Leptæna euglypha*, *Pentamerus galeatus*, and others, characterize, at least *by predominance* (as particular plants may be said to characterize certain soils), the Upper Silurian strata.

In like manner *Atrypa hemispherica*, and *A. lens*; *Hypothyris decemplicata*, and *H. furcata*; *Orthis flabellulum*, and *vespertilio*; *Pentamerus lævis*, and others predominate in Lower Silurian, though like *Lept. sericea*, they may sometimes transgress the line and appear in Wenlock shales.

TABLE XVII.—*Geological Distribution of Brachiopoda in the Llandilo Region.*

Names of Species.	Strata in Descending Order.			Names of Species.	Strata in Descending Order.		
	Tilestone Band.	Mydelton Group.	Llandilo Limestone Series.		Tilestone Band.	Mydelton Group.	Llandilo Limestone Series.
Lingula granulata	·	·	●	Orthis calligramma	·	·	●
—— Lewisii	●	·	·	—— compressa	·	·	●
Atrypa crassa	·	●	●	—— corrugata	·	·	●
—— depressa	·	·	●	—— costata	·	·	·
—— didyma	●	●	·	—— elegantula	·	●	●
—— globosa	·	●	●	—— expansa	·	·	●
—— lens	·	●	●	—— flosa	·	●	·
—— reticularis	·	●	●	—— flabellulum	·	·	●
—— var. orbicularis	·	●	·	—— inflata	·	·	●
—— tumida	·	●	·	—— insularis	·	·	●
—— undata	·	·	●	—— lata	·	·	●
Hypothyris bidentata	·	●	·	—— lunata	●	·	·
—— borealis	·	●	·	—— opercularis	·	·	●
—— crispata	·	●	·	—— orbicularis	●	●	·
—— deflexa	·	●	·	—— radians	·	·	●
—— marginalis	·	·	●	—— reversa	·	·	●
—— navicula	·	●	·	—— testudinaria	·	·	●
—— semisulcata	·	●	·	—— vespertilio	·	·	●
—— Wilsoni	●	●	·	Pentamerus galeatus	·	●	·
Leptæna depressa	·	●	●	—— lævis	·	·	●
—— euglypha	·	●	●	—— oblongus	·	·	●
—— funiculata	·	●	·	Spirifera cyrtæna	·	●	·
—— lepisma	·	●	·	—— interlineata	·	·	●
—— var. minor	·	●	·	—— biforata	·	·	●
—— sarcinulata	●	●	·	—— octoplicata	·	●	·
—— sericea	·	●	●	—— ptychodes	·	·	·
—— tenuistriata	·	●	●	—— trapezoidalis	·	●	·
—— transversalis	·	●	●				
Orthis Actonia	·	●	●	Number of Species in each group of Strata	6	32	34
—— alternata	·	·	●				
—— biloba	·	●	●				

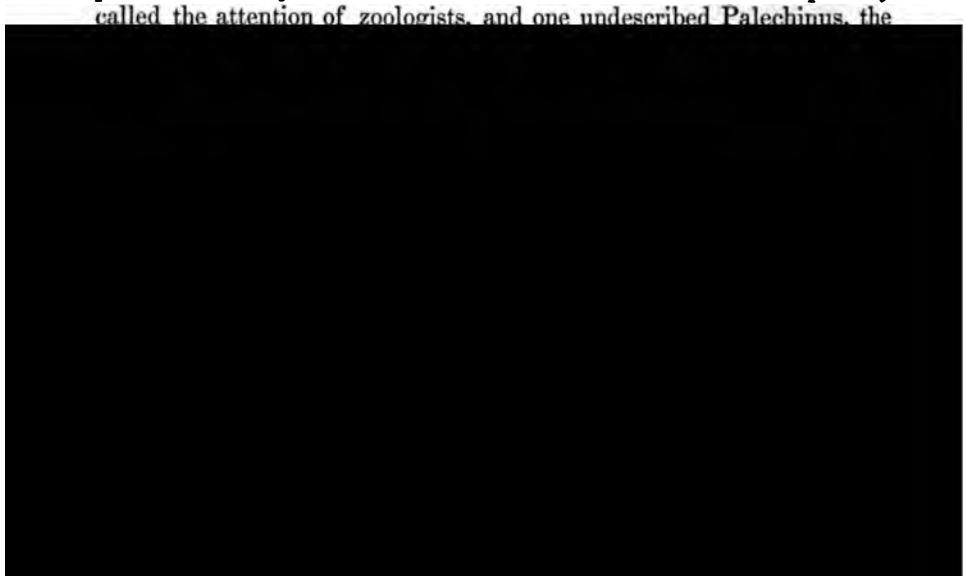
As identifying one certain stratum, few of the Brachiopoda can be safely quoted. The distribution of *Pentam. Knightii* is perhaps as much a local as a geological peculiarity; *Leptæna euglypha*, and *L. sarcinulata* (*lata*), are found in a much wider range of deposits than was expected; though, like *Terebratula Wilsoni*, and *T. navicula*, their abundance on some particular surfaces of strata indicates particular epochs more than commonly favourable to their multiplication and conservation. Specimens of *Atrypa reticularis* are nowhere so large as

in or near to the Aymestry Rock, from which also are usually gathered the finest examples of *Lingula Lewisii*. It is in fact not so much by the mere occurrence of certain fossils, as by the association of species, their relative abundance, the manner of their accumulation, and generally by all the circumstances connected with them which mark certain coincident physical conditions, that the problem of identifying strata is solved by the well-instructed palæontologist.

The remarks already offered on the distribution of the Brachiopoda in the Eastern region, would be found to apply in many particulars to the geological range of these shells in the Western regions, and especially in that of Llandilo, did we feel quite justified in subdividing the Myddelton group into stages corresponding minutely to those of Malvern. This is a thing not so much impracticable as undesirable, because of the great differences in the successive physical conditions of the Malvern and Llandilo regions. Using the same classification of strata as heretofore, we find the maximum of life in the middle group, but the superiority of this group, when compared with that of Llandilo, is but small. Probably a portion of the localities which we have included in the Lower Llandilo, or flag series, might with quite as much reason have been given to the Myddelton group (as being really equivalents of the Wenlock shale), and thus the analogy of the Llandilo and Malvern regions would have been more complete.

ECHINODERMATA.

The few species of Echinodermata which the following list contains, are of considerable interest, from their including so considerable a proportion of the Cystidea, to which Von Buch and Forbes have specially called the attention of zoologists, and one undescribed Palechinus, the



CYATHOCRINITES? MACROSTYLUS, Phillips.

REF.—Palæontological Appendix.

Woolhope District . . Perton. Stoke Edith.

CYATHOCRINITES PYRIFORMIS.

REF.—Murchison, Sil. Syst., t. 17, f. 6.

Malvern District . . Under Worcester Beacon in Caradoc conglomerate.

CYATHOCRINITES RUGOSUS.

REF.—Murchison, Sil. Syst., t. 18, f. 1.

Abberley District . . Hill End, W.L. Callow Farm.
Woolhope District . . Dormington Wood.
Usk District. . . . Cilfigan.

DIMEROCRINITES ICOSIDACTYLUS.

REF.—Murchison, Sil. Syst., t. 17, f. 4.

Marloes District . . Slate Mill.

HYPANTHOCRINITES DECORUS.

REF.—Murchison, Sil. Syst., t. 17, f. 3.

Malvern District . . Under Worcester Beacon in Caradoc conglomerate.

RHODOCRINITES? QUINQUANGULARIS.

REF.—Murchison, Sil. Syst., t. 18, f. 5.

May Hill District . . Between Rock Farm and Dursley, W.S.
Llandilo District . . Llandilo.
Haverfordwest District. Robeston Wathen.

There are undoubtedly more species: but columnar joints, and a few scattered plates, will seldom suffice to identify any but the most completely known Crinoidea.

CARYOCYSTITES GRANATUM.

REF.—Von Buch, Uber Cystideen, t. 1, f. 8–10.

CARYOCYSTITES LITCHI, Forbes.

REF.—Palæontological Appendix.

HEMICOSMITES OBLONGUS?

REF.—Pander, Beitrage, t. 2, f, 23.

(From Shole's Hook, in the Haverfordwest district.)

HEMICOSMITES? RUGATUS, Forbes.

REF.—Palæontological Appendix.

Haverfordwest District. Great Cresswell.

CYSTIDEA.

SPHÆRONITES ARACHNOIDEUS, Forbes.

REF.—Palæontological Appendix.

SPHÆRONITES BALTICUS.

REF.—Murchison and De Verneuil, Geol. Russia, vol. ii., pl. 1, f. 9.

SPHÆRONITES AURANTIUM.

REF.—Murchison and De Verneuil, Geol. Russia, vol. ii., pl. 27, f. 6, and pl. 1, f. 8; Von Buch, Uber Cystideen, t. 1, f. 21, 22.

(From Shole's Hook, in the Haverfordwest district.)

ECHINIDA.

PALECHINUS PHILLIPSIÆ, Forbes.

REF.—Palæontological Appendix.

Malvern District . . From the Caradoc conglomerate under Worcester Beacon.

TABLE XVIII.—*Geographical Distribution of Echinodermata.*

NAMES OF SPECIES.	Western Districts.						Eastern Districts.						No. of Occurrences of each Species.	No. of Districts in which each Species occurs.
	Marloes.	Freshwater.	Haverfordwest.	Caermarthen.	Llandilo.	Builth.	Usk.	Tortworth.	May Hill.	Woolhope.	Abberley.	Malvern.		

[redacted]

POLYPIARIA.

ACERVULARIA BALTICA.

REF.—Murchison, Sil. Syst., t. 16, f. 8.

Malvern District . . Ledbury, W.L.
Woolhope District . . Dormington Wood.

ALVEOLITES FIBROSA.

REF.—Murchison, Sil. Syst., t. 15, f. 1.

Malvern District . . Brock Hill, U.L. Bason Court Farm, A.L.
Abberley District . . Hole Farm, U.L.
Woolhope District . . Welch Court. Bodenham, U.L. Shucknall Farm. Backbury, A.L. Shucknall Hill.
Usk District . . . Cefn Ila, L.L.
Builth District . . . Cwm Craig ddu, U.L.
Llandilo District . . Gilfach. Pen cae sarah.

AULOPORA SERPENS.

REF.—Murchison, Sil. Syst., t. 15, f. 6.

Malvern District . . Eastnor Park.
Abberley District . . Hill End, W.L. Abberley. Callow Farm.
Woolhope District . . Woolhope, WP.L. Dormington Wood.
Builth District . . . Aberedw, U.L.
Llandilo District . . Swansea Road, 4. River Sawdde. Golden Grove. Swansea Road, 4.
Marloes District . . Marloes Bay.

AULOPORA TUBÆFORMIS.

REF.—Murchison, Sil. Syst., t. 15, f. 8.

Woolhope District . . Dormington Wood.

AULOPORA CONSIMILIS.

REF.—Murchison, Sil. Syst., t. 15, f. 7.

Woolhope District . . Dormington Wood.

AULOPORA CONGLOMERATA.

REF.—Murchison, Sil. Syst., t. 15, f. 9.

Woolhope District . . Dormington Wood.

CATENIPORA ESCHAROIDES.

REF.—Murchison, Sil. Syst., t. 15 *bis*, f. 14.

Malvern District . . Ledbury. East of Ledbury. Clincher's Mill. Eastnor Park.
Abberley District . . Abberley.
Woolhope District . . Dormington Wood.
May Hill District . . Rock. West of Rock. South of Rock, W.S. Huntley Hill. May Hill.
Usk District . . . Ty Newydd. Trostra. Radyr. Cilorgyr.

Carmarthen District . Lett yr Hendref. (N.E. of Caermarthen.)
Llandilo District . . Llandovery. Cefn Rhyddan. Goleugoed. Cefn Garreg. Castell Drwysllwyn.
Haverfordwest District . Llandowror. Robeston Wathen. Veynor fach.

CARYOPHYLLIA FLEXUOSA.

REF.—Murchison, Sil. Syst., t. 16, f. 7.

Malvern District . . Malvern, W.S. (Murchison).
Llandilo District . . Goleugoed.

CERIOPORA GRANULOSA.

REF.—Murchison, Sil. Syst., t. 15, f. 29.

Malvern District . . Ledbury (Murchison).
Usk District . . . S.E. of Radyr. Trostra. Cilorgyr.
Llandilo District . . Llwych gwyn.

CYATHOPHYLLUM CÆSPITOSUM.

REF.—Murchison, Sil. Syst., t. 16, f. 10.—*Lithodendron*, Keyserling.

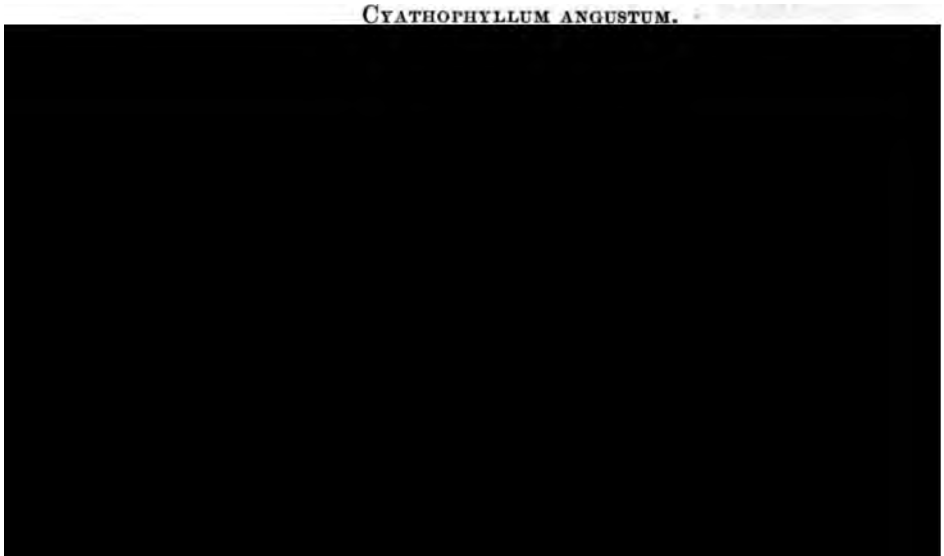
Malvern District . . Eastnor Park.
Woolhope District . . East of Canwood. Dormington. Lindels.
Usk District . . . Llanbadoc, A.L. Llangibby, A.L. Cilorgyr. Cilfigan.
Haverfordwest District . Hooton Quarry.

CYATHOPHYLLUM DIANTHUS.

REF.—Murchison, Sil. Syst., t. 16, f. 12.

Malvern District . . Eastnor Park.
Abberley District . . Hill End.
Woolhope District . . Dormington Wood.
May Hill District . . Rock. West of Rock Farm.
Usk District . . . Trostra. Cilorgyr.

CYATHOPHYLLUM ANGUSTUM.



Woolhope District . . Shucknall, A.L. South of Putley, A.L. Backbury Camp. Bodenham, A.L. North of Canwood. East of Canwood. Lindels. Dormington Wood. Checkley Common, W.S. South of Woolhope, WP. L. Stoke Edith. Ecknall Copse.

May Hill District . . Longhope, U.L. Rock. West of Rock Farm. Near Dursley Cross. South of the Rock, W.S.

Usk District . . Ty Newydd. Cilorgyr. Llanbadoc, A.L.

Builth District . . . Builth. Presteign Road.

Llandilo District . . Near Llangadoc.

Haverfordwest District . Shole's Hook. Robeston Wathen. Fron Veynor fach. Llandowror.

Marloes District . . Marloes Mill.

CYSTIPHYLLUM SILURIENSE.

REF.—Murchison, Sil. Syst., t. 16 *bis*, f. 1, 2.

Woolhope District . . Dormington Wood. East of Canwood.

Usk District . . . Prescoed. Ty Newydd.

CYCLOLITES PRÆACUTA.

REF.—Murchison, Sil. Syst., t. 15, f. 4.

Marloes District . . Marloes Bay, 1 a, 4.

CYCLOLITES LENTICULATA?

REF.—Murchison, Sil. Syst., t. 15, f. 5.

Marloes District . . Marloes Bay, 4.

ESCHARA SCALPELLUM.

REF.—Murchison. Sil. Syst., t. 15, f. 25.

Malvern District . . In conglomerate under Worcester Beacon.

Abberley District . . Hill End, W.L.

Woolhope District . . East of Canwood.

Usk District. . . . Trostra. Cilorgyr.

Llandilo District . . Llandilo.

FAVOSITES ALVEOLARIS.

REF.—Murchison, Sil. Syst., t. 15 *bis*, f. 1, 2.

Malvern District . . Gunwick Mill, U.C. Howler's Heath. Under Worcester Beacon, WP.L. Storridge. Ledbury. East of Ledbury. Eastnor Park. Clincher's Mill. Dog Hill. In conglomerate under Worcester Beacon.

Abberley District . . Hill End, L.L. Hill End, W.L. Abberley. Collins' Green.

Woolhope District . . North of Canwood. East of Canwood. Dormington Wood. Lindells. Bodenham, A.L.

May Hill District . . Rock Farm. Huntley, May Hill. South of Rock.
Usk District . . . Ty Newydd. Cilorgyr. Trostra. Dowlas. Near Usk, in L.L. Llanbadoc, A.L. Llangibby, A.L. Lancayo.
Builth District . . . Erw Gilfach.
Llandilo District . . Pen cerrig. Pwll Calch. Llandovery. Cerrig gwynion. Mandinam. Castell Craig gwyddon. Goleugoed.
Marloes District . . Wooltack. Marloes Mill. Marloes Bay, D.E.

FAVOSITES FAVULOSA, Phillips.

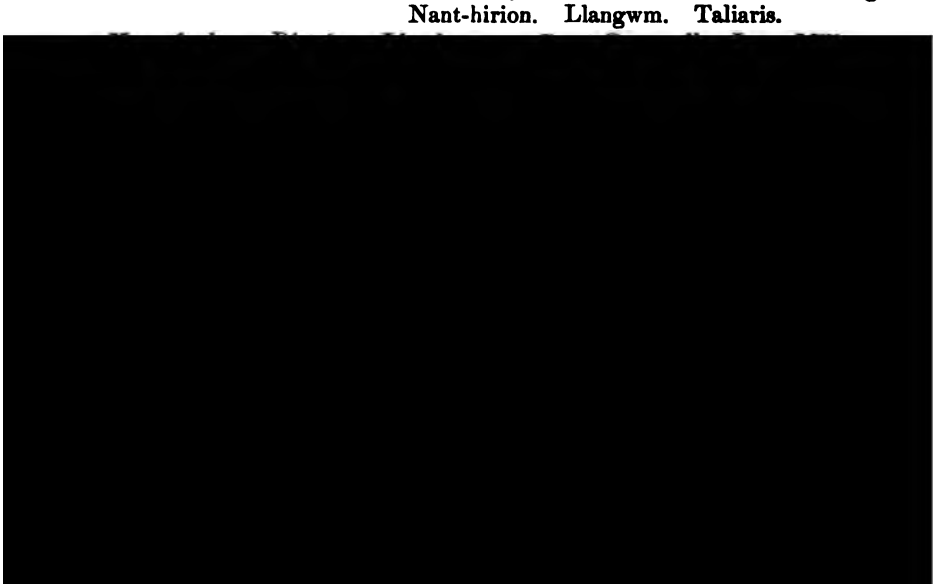
REF.—Palæontological Appendix.

Llandilo District . . Golden Grove, 1.
Haverfordwest District. Lann Mill.

FAVOSITES FIBROSA.

REF.—Murchison, Sil. Syst., t. 15 *bis*, f. 7.

Malvern District . . Eastnor Park. Under Hereford Beacon.
Abberley District . . Hill End, W.L. Hole Farm, L.L. Callow Farm.
Woolhope District . . Dormington Wood. Bodenham, A.L. South of Putley.
Usk District . . . Trostra. Cilorgyr. Cilfigan. Cefn Ila. Radyr. Dowlas. Prescoed. Tynewydd. Craig y Garcyd. Tucking Mill. Llanbadoc, A.L.
Builth District . . . Aberedw, U.L. Erw Gilfach.
Llandilo District . . Pwll Calch. Carreg gwynion. Castell Craig gwyddon. Goleugoed. Bwlch-Trebannau. Llandilo. Bird's Hill. Golden Grove, 4. Keeper's Lodge. Myddelton Park. Grug. Drwysllwyn. Swansea Road, 5. Tregib. Nant-hirion. Llangwm. Taliaris.



FAVOSITES MULTIPORA.

REF.—Murchison, Sil. Syst., t. 15 *bis*, f. 5.

Malvern District . .	East of Ledbury. Swinyard Hill (Pass). Hereford Beacon. Eastnor Park, WP. L., W. L. Hay Close Wood. In conglomerate under Worcester Beacon.
Abberley District . .	Ankerdine Hill, U.C.
Usk District . . .	Cilorgyr.
Llandilo District . .	Allt ddu.
Haverfordwest District .	Priory Mill.

FAVOSITES RAMULOSA, Phillips.

REF.—Palæontological Appendix.

Malvern District . .	Brock Hill. Hale's End.
Abberley District . .	Ridge Hill, A.L.
May Hill District . .	Huntley, U.C.
Llandilo District . .	Golden Grove, 1. 2.
Haverfordwest District .	Lann Mill. Priory Mill. Robeston Wathen.
Marloes District . .	Marloes Bay. Wooltack Bay. Slate Mill. Great Hooton. Lindsway.

FAVOSITES SPONGITES.

REF.—Murchison, Sil. Syst., t. 15 *bis*, f. 8.

Malvern District . .	Wych, U.C. In conglomerate under Worcester Beacon.
Abberley District . .	Callow Farm.
Woolhope District . .	Dormington Wood. Shucknall Hill, A.L.
May Hill District . .	Rock. South of Rock.
Usk District . . .	Radyr. Trostra. Llanbadoc, A.L.
Builth District . . .	Erw Gilfach.
Llandilo District . .	Goleugoed. Llangwm.

FAVOSITES POLYMORPHA.

REF.—Murchison, Sil. Syst., t. 15, f. 2.

Woolhope District .	East of Canwood. North of Canwood. Dormington Wood.
May Hill District . .	Rock. West of Rock Farm.
Usk District . . .	Cilorgyr.
Marloes District . .	Slate Mill.

FENESTELLA ANTIQUA.

REF.—Murchison, Sil. Syst., t. 15, f. 16.

Abberley District . .	Hill End. Callow Farm.
Woolhope District . .	North of Canwood. Dormington Wood.
May Hill District . .	Rock.
Usk District . . .	Trostra. Cilorgyr. Cilfigan. Dowlas.

Haverfordwest District. Veynor fach. Shole's Hook.
Marloes District . . Marloes Bay? Slate Mill. Hooton. Lindsway.

FENESTELLA MILLERI.

REF.—Murchison, Sil. Syst., t. 15, f. 17.

Woolhope District . . Dormington Wood.

GORGONIA ASSIMILIS.

REF.—Murchison, Sil. Syst., t. 15, f. 27.

Malvern District . . Alfrick (Murchison), W.S.
Woolhope District . . Dormington Wood.
Haverfordwest District. Llandowror. Robeston Wathen. Priory Mill. Shole's Hook.
Marloes District . . Slate Mill.

GRAPTOLITHUS LUDENSIS.

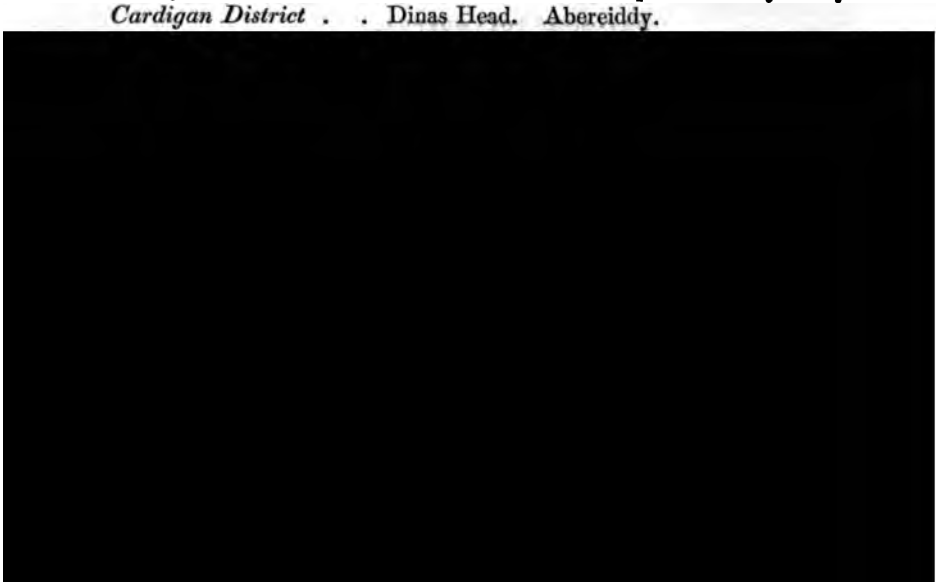
REF.—Murchison, Sil. Syst., t. 26, f. 1.

Malvern District . . Eastnor (South of Castle), L.L.
Abberley District . . Hole Farm, L.L.
May Hill District . . May Hill.
Builth District . . . Aberedw, L. L. Llanfaredd. Builth, W. S. East of Builth, W.S. Presteign Road, W.S. Wellfield.
Llandilo District . . Melin y cwm. Llangadoc.
Haverfordwest District. Llandowror. Lann Mill.

GRAPTOLITHUS MURCHISONII?

REF.—Murchison, Sil. Syst., t. 26, f. 4.

Builth District . . . Builth, W.S. East of Builth, W.S.
Llandilo District . . Pwll-llacca.
Haverfordwest District Near St. Clair's. Lampeter Velfrey. Mydrim.
Cardigan District . . Dinas Head. Abereiddy.



HETEROPORA CRASSA.

REF.—Murchison, Sil. Syst., t. 15, f. 14.

Abberley District . . Hill End. Ridge Hill Farm.

LIMARIA CLATHRATA.

REF.—Murchison, Sil. Syst., t. 16 *bis*, f. 7.

Abberley District . . Hill End. Abberley. Callow Farm.
Woolhope District . . Dormington Wood. Lindels.
May Hill District . . Rock. South of Rock.
Usk District . . . Cilorgyr. Cilfigan.

LIMARIA FRUTICOSA.

REF.—Murchison, Sil. Syst., t. 16 *bis*, f. 8.

Malvern District . . Ledbury.
Abberley District . . Abberley.
Woolhope District . . Dormington Wood.
May Hill District . . Rock Farm. South of Rock.

MILLEPORA REPENS.

REF.—Murchison, Sil. Syst., t. 15, f. 30.

Malvern District . . In conglomerate under Worcester Beacon, U.C. Mathon, W.L.
Abberley District . . Hill End. Abberley. Callow Farm.
Woolhope District . . North of Canwood. East of Canwood. Dormington Wood. Lindels.
Usk District . . . Ty Newydd. Cilorgyr.

MONTICULARIA CONFERTA.

REF.—Murchison, Sil. Syst., t. 16, f. 5.

Abberley District . . Hill End.
Woolhope District . . East of Canwood.

PETRAIA BINA.

REF.—*Turbinolopsis bina*, Murchison, Sil. Syst., t. 16 *bis*, f. 5.

Malvern District . . Gunwick, U.C. Worcester Beacon, U.C. Wych. Howler's Heath. Clincher's Mill, W.L. Conglomerate under Worcester Beacon.
Abberley District . . Ankerdine Hill, U.C.
Woolhope District . . Haugh Wood.
May Hill District . . May Hill. Huntley Hill.
Usk District . . . Llanbadoc, A.L. Llangibby, A.L.
Builth District . . . Erw Gilfach. Presteign Road. Pen Cerrig.
Llandilo District . . Pwll Calch. Llwyn y ricet. Golden Grove, 4. Near Myddfai. Bwlch-Trebanmau. Carreg gwynion. Mandinam. Castell Craig gwyddon. Goleugoed. Llandovery. Llangwm.

Haverfordwest District . Great Cresswell. Pan-blewin. Priory Mill.
Marloes District . . Marloes Bay. Wooltack Bay. Marloes Mill.

PETRAIA ELONGATA.

REF.—Phillips, Palæozoic Fossils of Devon, &c., t. 2, f. 6 b.

Malvern District . . In conglomerate under Worcester Beacon.
May Hill District . . May Hill, U.C.
Usk District . . . Lancayo Hill?
Builth District . . . Pen Cerrig grits.
Llandilo District . . Bwlch-Trebannau. Castell Craig gwyddon. Goleugoed. Cefn Rhyddan. Swansea Road, 4.
Haverfordwest District . Moor.

PORITES EXPATIATA.

REF.—Murchison, Sil. Syst., t. 15, f. 3.

Malvern District . . Clincher's Mill.
Woolhope District . . Lindels (Murchison). Dormington Wood.
May Hill District . . Aston Ingham.
Haverfordwest District . Crinow.

PORITES INORDINATA.

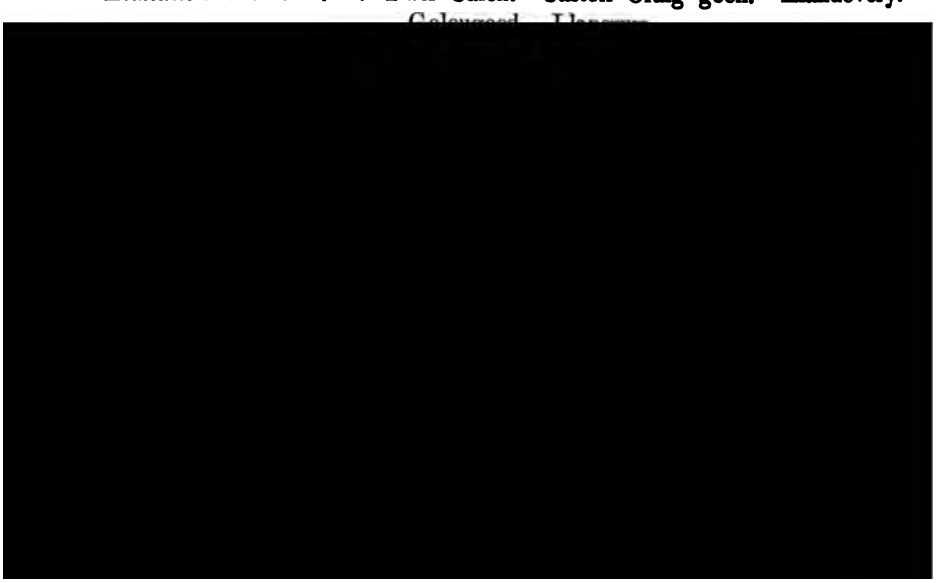
REF.—Murchison, Sil. Syst., t. 16 *bis*, f. 12.

Haverfordwest District . Robeston Wathen. Upper Moor.

PORITES PYRIFORMIS.

REF.—Murchison, Sil. Syst., t. 16, f. 2.

Malvern District . . Fair Oaks, U. C. Storridge, W.L. Clincher's Mill. Eastnor Park, &c. In conglomerate under Worcester Beacon.
Abberley District . . Abberley. Callow Farm. Fetlocks Farm.
Woolhope District . . Dormington Wood. East of Canwood.
May Hill District . . Rock. West of Rock Farm. South of Rock.
Usk District . . . Radyr. Trostra.
Llandilo District . . Pwll Calch. Castell Craig goch. Llandovery. Goleugoed. Llangyn



Llandilo District . . Cefn Llwydlo. Llangwm. Taliaris. Park Lodge. Bird's Hill.
Haverfordwest District . Great Cresswell. Robeston Wathen. Priory Mill. Lann Mill.

PTILODICTYA LANCEOLATA.

REF.—Murchison, Sil. Syst., t. 15, f. 11.

Malvern District . . Mathon. Ledbury. Rilbury. A.L. Bason Court, A.L.
Woolhope District . . Bodenham, A.L. Stoke Edith. Shucknall, A.L.
Tortworth District . . Long's Quarry, U.C.
Usk District . . . Radyr.
Marloes District . . Slate Mill.

RETEPORA INFUNDIBULUM.

REF.—Murchison, Sil. Syst., t. 15, f. 24.

Marloes District . . Lindsway?

STROMATOPORA CONCENTRICA.

REF.—Murchison, Sil. Syst., t. 15, f. 31.

Woolhope District . . Dormington Wood.
Usk District . . . Usk, U.L., L.L. Llanbadoc, A.L. Dowlas Farm. Cilfigan. Prescoed. Craig y garcyd. Tucking Mill.
Builth District . . . Cwm Craig ddu.
Llandilo District . . Castell Craig gwyddon.
Marloes District . . Marloes Mill.

STROMBODES PLICATUM.

REF.—Murchison, Sil. Syst., t. 16 *bis*, f. 4.

Malvern District . . West of Malvern Hill (Murchison).
May Hill District . . Rock Farm.

SYRINGOPORA BIFURCATA.

REF.—Murchison, Sil. Syst., t. 15 *bis*, f. 11.

Woolhope District . . Dormington Wood.
Usk District . . . Ty Newydd.

SYRINGOPORA CÆSPITOSA.

REF.—Murchison, Sil. Syst., t. 15 *bis*, f. 13.

Woolhope District . . Dormington Wood.

SYRINGOPORA FILIFORMIS.

REF.—Murchison, Sil. Syst., t. 15 *bis*, f. 12.

Malvern District . . Eastnor Park.
Abberley District . . Ridge Hill Farm, A.L.

Woolhope District . . Dormington Wood.
Usk District . . . Cefn Ila. Prescoed. Ty Newydd. Trostra.

SYRINGOPORA RETICULATA.*

REF.—Murchison, Sil. Syst., t. 15 *bis*, f. 10.

Usk District . . . Cilorgyr. Trostra. Prescoed.

VERTICILLIPORA ABNORMIS.

REF.—Murchison, Sil. Syst., t. 16 *bis*, f. 10.

Malvern District . . Hereford Beacon.
Llandilo District . . Goleugoed. Dynevor. Bird's Hill Quarry.
Marloes District . . Marloes Mill.

PLANTS.

The remains of Plants are of limited occurrence in the rocks of the Malvern district, but traces of marine vegetation occur in the lower sandstones (volcanic grits) of the Malvern Hills, on the London road from Eastnor; a distinctly dichotomous fucoid is often seen in the thin beds of the Upper Caradoc sandstones; some other fucoidal reliques appear in the Wenlock shales, and carbonaceous spots and marks of terrestrial? plants characterize the lowest parts of the Old Red Sandstone, rarely at Malvern, abundantly about Stoke Edith and Dormington, and other localities in the Woolhope district, and near the Rock, in the vicinity of May Hill. In these latter examples the black oval carbonaceous pellets, resembling pebbles, abound; and with them occurs rarely a large Lingula. Long parallel leaf-like markings may also be seen, especially at Dormington.

ACTINOPHYLLUM, Phillips.

REF.—Palæontological Appendix.

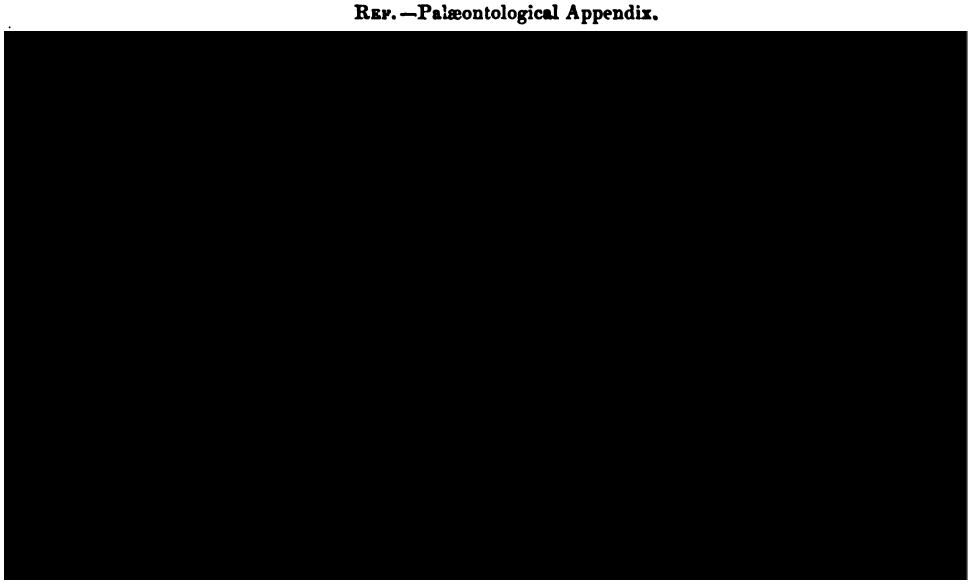


TABLE XIX.—*Geographical Distribution of Polypiaria.*

MES OF SPECIES.	Western Districts.							Eastern Districts.						No. of Occurrences of each Species.	No. of Districts in which each Species occurs.
	Cardigan.	Marloes.	Freshwater.	Haverfordwest.	Carmarthen.	Llandilo.	Builth.	Usk.	Tortworth.	May Hill.	Woolhope.	Abberley.	Malvern.		
ia Baltica	.	.	.	.	.	.	.	.	.	.	1	.	1	2	2
s fibrosa	.	.	.	.	.	12	1	1	.	.	5	1	2	12	6
serpens	.	1	.	.	.	4	1	.	.	.	2	3	1	12	6
tubæformis	.	.	.	.	.	.	.	.	.	.	1	.	.	1	1
consimilis	.	.	.	.	.	.	.	.	.	.	1	.	.	1	1
conglomerata	.	.	.	.	.	.	.	.	.	.	1	.	.	1	1
a escharoides	.	.	.	3	1	5	.	4	.	5	1	1	4	24	8
llia flexuosa	.	.	.	.	.	1	.	.	.	.	.	.	1	2	2
granulosa	.	.	.	.	.	1	.	3	.	.	.	.	1	5	3
yllum cæspitosum	.	.	.	1	.	.	.	4	.	.	3	.	1	9	4
—— dianthus	.	.	.	.	.	.	.	2	.	2	1	1	1	7	5
—— angustum	.	.	.	.	.	.	.	.	.	2	1	.	.	3	2
—— turbinatum	.	1	.	5	.	1	2	3	.	5	12	3	9	41	9*
llum Siluriense	.	.	.	.	.	.	.	2	.	.	2	.	.	4	2
præacuta	.	1	.	.	.	.	.	.	.	.	.	.	.	1	1
lenticulata	.	1	.	.	.	.	.	.	.	.	.	.	.	1	1
calpellum	.	.	.	.	.	1	.	1	.	.	1	1	1	5	5
alveolaris	.	3	.	.	.	7	1	8	.	4	5	4	10	42	8
favulosa	.	.	.	1	.	1	.	.	.	.	.	.	.	2	2
fibrosa	.	2	2	3	.	17	2	11	.	.	3	3	2	45†	9*
Gottlandica	.	1	1	.	.	2	.	4	.	1	1	.	1	11	7
multipora	.	.	.	1	.	1	.	1	.	.	.	1	7	11	5
ramulosa	.	5	.	3	.	2	.	.	.	1	.	1	2	14	6
spongites	.	.	.	.	.	2	1	3	.	2	2	1	2	13	7
polymorpha	.	1	.	.	.	.	.	1	.	2	3	.	.	7	4
antiqua	.	4	.	2	.	.	.	4	.	1	2	2	.	15	6
Milleri	.	.	.	.	.	.	.	.	.	.	1	.	1	1	1
assimilis	.	1	.	4	.	.	.	.	.	.	1	.	1	7	4
hus Ludensis	.	.	.	2	.	2	6	.	.	1	.	1	1	13	6
— Murchisonii	1	.	.	3	.	1	2	.	.	.	.	.	.	7	4
— pristis	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
a crassa	.	.	.	.	.	.	.	.	.	.	.	2	.	2	1
lathrata	.	.	.	.	.	.	.	2	.	2	2	3	.	9	4
ruticosa	.	.	.	.	.	.	.	.	.	.	1	1	1	5	4
repens	.	.	.	.	.	.	.	1	.	.	4	3	2	10	4
aria conferta	.	.	.	.	.	.	.	.	.	.	1	1	.	2	2
na	.	3	.	3	.	11	3	2	.	2	1	1	6	32	9*
ongata	.	.	.	1	.	5	1	1	.	1	.	.	1	10	6
patiata	.	.	.	1	.	.	.	.	.	1	2	.	1	5	4
ordinata	.	.	.	2	.	.	.	.	.	.	.	.	.	2	1
riformis	.	1	.	2	.	5	.	2	.	3	2	3	5	23	8
bulata	.	.	.	1	.	.	.	.	.	1	1	2	1	6	5
a dichotoma	.	.	.	4	.	5	2	.	.	.	.	.	.	11	3
— lanceolata	.	1	.	.	.	.	.	1	1	.	3	.	4	10	5
infundibulum	.	1	.	.	.	.	.	.	.	.	.	.	.	1	1
ora concentrica	.	1	.	.	.	1	1	8	.	.	1	.	.	12	5
es plicatum	.	.	.	.	.	.	.	.	.	1	.	.	1	2	2
ra bifurcata	.	.	.	.	.	.	.	1	.	.	1	.	.	2	2
— cæspitosa	.	.	.	.	.	.	.	.	.	.	1	.	.	1	1
— filiformis	.	.	.	.	.	.	.	4	.	.	1	1	1	7	4
— ramulosa	.	.	.	.	.	.	.	2	.	.	.	.	.	2	1
— reticulata	.	.	.	.	.	.	.	2	.	.	.	.	.	2	1
ora abnormis	.	1	.	.	.	3	.	.	.	.	.	.	1	5	3
ccurrences in each	1	29	3	42	1	81	23	78	1	39	71	40	72	481	.
ecies in each District	1	17	2	18	1	23	12	26	1	19	34	22	29	.	.

Number of Species admitted, 53. West 34 45 East.

Number of Occurrences admitted, 481. West 180 301 East.

TABLE XX.— *Geological Distribution of Polypiaria in the Eastern Region.*

NAMES OF SPECIES.	STRATA IN DESCENDING ORDER.												No. of Occurrences of each Species.	No. of Strata in which each Species occurs.
	Downton Sandstone.	Upper Ludlow.	Aymestry Rock.	Lower Ludlow.	Wenlock Limestone.	Wenlock Shale.	Woolhope Limestone.	Upper Caradoc.	Lower Caradoc.	Trap.	Black Shale.	Lowest Sandstone.		
Acervularia Baltica					*								12	1
Alveolites fibrosa		*	*	*	*								9	3
Aulopora serpens					*	*	*						6	2
——— tubæformis					*								1	1
——— consimilis					*								1	1
——— conglomerata					*								1	1
Catenipora escharoides					*	*							15	3
Caryophyllia flexuosa					*	*							1	1
Ceriopora granulosa		*			*								4	2
Cyathophyllum cæspitosum			*		*								8	2
——— dianthus					*								7	1
——— angustum					*								3	1
——— turbinatum		*	*	*	*	*	*	*					32	7†
Cystiphyllum Siluriense					*								4	1
Eschara scalpellum					*			*					4	2
Favosites alveolaris			*	*	*	*	*	*					31	6
——— fibrosa			*	*	*	*		*					19	4
——— Gottlandica			*	*	*	*		*					7	3
——— multipora					*			*					9	3
——— ramulosa		*	*		*			*					4	3
——— spongites			*		*	*							10	4
——— polymorpha					*								6	1
Fenestella antiqua					*								9	1
——— Milleri					*								1	1
Gorgonia assimilis					*	*							12	2
Graptolithus Ludensis				*									3	1
Heteropora crassa			*		*								12	2
Limaria clathrata					*	*							9	2
——— fruticosa					*								5	1
Millepora repens					*			*					10	2
Monticularia conferta					*			*					12	1
Petraia bina			*		*			*					12	3
——— elongata			*?		*			*					3	2
Porites expatiata					*								4	1
——— pyriformis					*								15	3
——— tubulata					*	*							5	2
Ptilodictya lanceolata			*		*			*					9	3
Stromatopora concentrica		*	*	*	*	*							9	5

TABLE XXI.—*Geological Distribution of Polypiaria in the Llandilo Region.*

	Tilestone Group.	Myddelton Group.	Llandilo Group.	No. of Occurrences of each Species.	No. of Strata in which each Species occurs.
Alveolites fibrosa	.	*	.	.	1
Aulopora serpens	.	*	.	.	1
Catenipora escharoides	.	*	*	.	2
Caryophyllia flexuosa	.	.	*	.	1
Ceriopora granulosa	.	.	*	.	1
Cyathophyllum turbinatum	.	.	*	.	1
Eschara scalpellum	.	.	*	.	1
Favosites alveolaris	.	.	*	.	1
——— favulosa	.	.	*	.	1
——— fibrosa	.	*	*	.	2
——— Gottlandica	.	*	*	.	2
——— multipora	.	*	.	.	1
——— ramulosa	.	*	*	.	2
——— spongites	.	*	*	.	1
Graptolithus Ludensis	.	.	*	.	1
——— Murchisonii	.	.	*	.	1
——— pristis	.	.	*	.	1
Petraia bina	.	*	*	.	2
——— elongata	.	*	*	.	2
Porites pyriformis	.	*	*	.	2
Ptilodictya dichotoma	.	.	*	.	1
Stromatopora concentrica	.	.	*	.	1
Verticillipora abnormis	.	.	*	.	1
Number of Species in each Stratum	.	10	20	.	.

TABLE XXII.—*Summary of the Occurrences of each Class in each District.*

Classes.	Cardigan.	Marloes.	Freshwater.	Haverfordwest.	Carmarthen.	Llandilo.	Builth.	Usk.	Tortworth.	Mayhill.	Woolhope.	Abberley.	Malvern.	(A.) Total of Occurrences in each Class.	(B.) Total of Species of each Class.	(A/B.) Average of Occurrences to a Species.
Annelida	4‡	10	1	7	.	12	6	12	5	2	15	10	19*	109	13	8·4
Crustacea	.	19	3	44	1	80*	12	36	5	6	25	28	32	291	45	6·4
Cephalopoda	.	3	2	2	.	30*	7	19	3	3	20	10	29	128	28	4·6
Heteropoda	.	5	2	.	.	13	5	3	2	.	8	4	14*	56	10	5·6
Pteropoda	.	1	.	1	.	4*	2	2	.	.	1	3	3	17	3	5·7
Gasteropoda	.	13	6	1	.	39	6	23	6	8	40	4	48*	196	44	4·5
Lamellibranchiata	.	17	7‡	1	1	77*	14	71	2	11	42	21	40	303	45	12·1
Brachiopoda	.	31‡	6	57‡	1	256*	60‡	172‡	8‡	67‡	199‡	101‡	210‡	1166	97	6·7
Echinodermata	.	2	.	8*	.	2	.	6	1	1	3	2	5	29	15	2·0
Polypiaria	1	29	3	42	1	81*	23	78	1	39	71	40	72	481	53	9·1
(C.) No. of Occurrences of Species in each District	5	130	30	163	4	594	135	424	33	137	424	223	472	2477	353	.
(D.) No. of Localities in each District	5	20	4	37	8	86	13	30	8	9	34	12	47	.	.	.
(C/D) Average Occurrences of Species in each District to one Locality	1	6·5	7·5	4·4	0·5	6·9	10·4	14·1	4·1	15·2	12·5	18·6	10·0	.	.	.

From the foregoing Table we may collect (1), the relative *richness*, in number and variety of animal remains, of each district, both in respect of the whole series and of the several classes of organization: (2), the *proportion* of the Silurian fauna occupied by each class in each district, and in the whole area; (3), the frequency of occurrence, or proportionate numerical *distributiveness*, of each class.

(1.) The *district* whose localities are richest in respect of occurrences of species of fossils $\frac{C}{D}$, appears to be that of Abberley. Generally the Eastern districts thus considered are the richest.

(2.) The *class* richest in respect of occurrences of fossils (A), and in species of fossils (B), appears to be that of *Brachiopoda*. (The mark *, is placed to the maximum number in each class, and the mark ‡, to the maximum in each district.)

(3.) The frequency of occurrence, or numerical distributiveness $\frac{A}{B}$, appears to be greatest (12·1) in Brachiopoda, least (2·0) in Echinodermata, the average being 7·9.

TABLE XXIII.—*Summary of the Species of each Class in each District.*

Classes.	Cardigan.	Marloes.	Freshwater.	Haverfordwest.	Carmarthen.	Llandilo.	Builth.	Usk.	Tortworth.	Mayhill.	Woolhope.	Abberley.	Malvern.	(E.) Sums of the Numbers taken horizontally.	(F.) Number of the Species in each Class.	$\left(\frac{E}{F}\right)$ Average Distributiveness of each Class.
Annelida	4	2	1	2	.	3	3	3	3	2	4	5	9*	41	13	3·1
Crustacea	.	9	3	16	1	24*	9	12	5	3	8	11	17	118	45	2·6
Cephalopoda	.	3	2	2	.	16*	4	10	3	3	9	6	14	72	28	2·6
Heteropoda	.	5	2	.	.	5	4	3	2	.	3	4	6*	34	10	3·4
Pteropoda	.	1	.	1	.	2	1	1	.	.	1	2	2	11	3	3·6
Gasteropoda	.	11	6	1	.	21	5	13	6	7	13	4	26*	113	44	2·6
Lamellibranchiata	.	12	7	1	1	30*	6	24	1	9	18	12	25	146	45	3·2

districts in which each species occurs, is greatest in Polypiaria and Brachiopoda; least in Echinodermata.

(5.) The district, richest in respect of *variety* of fossils, appears to be that of Abberley.

TABLE XXIV.—*Summary of the Species of each Class in each Stratum of the Eastern Region.*

—	Annelida.	Crustacea.	Cephalopoda.	Heteropoda.	Pteropoda.	Gasteropoda.	Lamellibranchiata.	Brachiopoda.	Echinodermata.	Polypiaria.	Number of Species in each Stratum.
Downton Sandstone	.	.	.	.	.	.	.	1	.	.	1
Upper Ludlow	7	10	12	4	2	16	19	20	1	5	96
Aymestry Rock	.	6	5	2	.	11	12	28	.	14	78
Lower Ludlow	1	6	3	.	2	4	9	27	.	16	68
Wenlock Limestone	2	11	7	2	1	4	9	38	2	40	116
Wenlock Shale	3	8	2	1	.	5	12	32	1	11	75
Woolhope Limestone	1	2	1	.	.	1	.	20	.	4	29
Upper Caradoc	2 or 3	4	1	3	.	10	1	29	2	13	66
Lower Caradoc	1	.	2	1	.	2	3	3	.	.	12
Trap	.	.	.	.	.	.	.	.	.	.	.
Black Shale	.	4	.	.	.	.	.	.	.	.	4
Lowest Sandstone	.	.	.	.	.	.	.	.	.	.	.
(I.) No. of Geological Occurrences	18	51	32	13	5	53	65	198	6	103	.
(K.) No. of Species	8	25	19	9	3	32	32	80	7	45	.
$\left(\frac{I.}{K.}\right)$ Average Geological range	2·2	2·0	1·7	1·5	1·7	1·7	2·0	2·5	0·9	2·3	.

(6.) We learn by this Table that the *geological range* of the Silurian species is, on the average of (260) species, such that the different species may be admitted, *on the average*, to range through two of the members of the Silurian system.

In this respect, the classes of Brachiopoda and Polypiaria appear at the head, ranging through 2·5 and 2·3, and the Echinodermata and Heteropoda at the foot, ranging through 1·5 and 0·9.

(7.) The maximum of *variety*, in Silurian life, appears in the Wenlock Limestone. If the variety of life were expressed by ordinates in a curve, this curve will have three elevations, viz., in Upper Caradoc (followed by a great depression in Woolhope Limestone); in Wenlock Limestone (followed by depression in Lower Ludlow); and in Upper Ludlow. At each end the ordinates = 0.

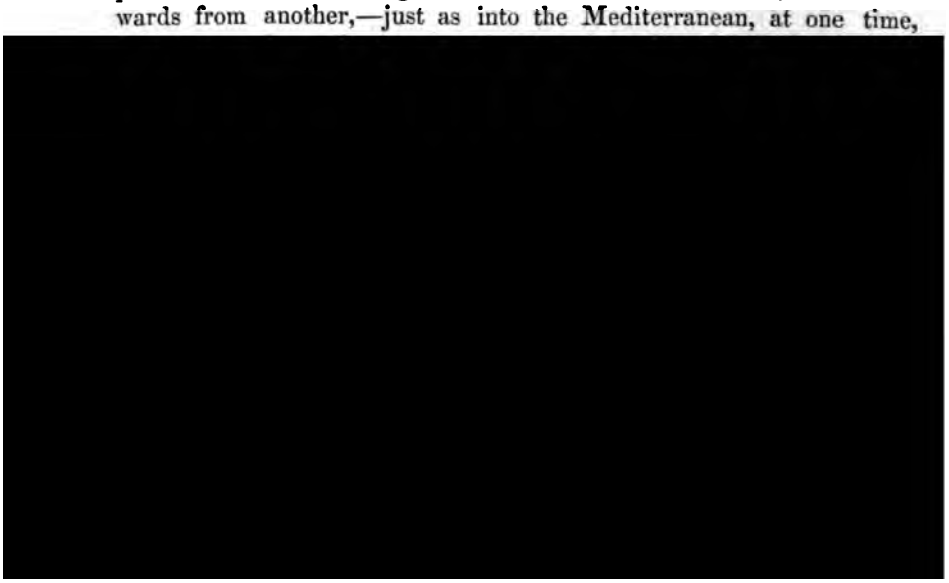
We may conclude from this, that at each of these three levels in the Silurian series—these three eras of Palæozoic time—the physical conditions of the Old Sea were especially favourable to the *development* of the germs of life. Perhaps we may allow of the *addition*, in or before each of these eras, of many forms not previously found in the area now under

consideration: but this addition is not accompanied by certain evidence of the *local creation* of new, or of the *local transformation* of old, species.

It appears often more probable that, with the mostly arenaceous mass of Upper Caradoc deposits, brought grain by grain, and layer by layer, with currents from a distance, a peculiar series of life came from other situations to flourish in this new area. This series decayed with the subsequent predominance of calcareo-argillaceous sediments (commencing in Woolhope Limestone,) and was by degrees replaced by a series of new forms, which arrived at the maximum in the most characteristic mass of these sediments (Wenlock Limestone), and then decayed, as the former races did, and gave place to a third fauna, rising to its maximum in the renewed arenaceous sediments of the Upper Ludlow beds. This third series was abruptly truncated by the introduction of a fourth group of sediments, without invertebral life, the peroxidated clays and sands of the old red group.

But though we thus in general distinguish the Silurian fauna, which has been examined, into three grand groups, developed in succession in conformity with certain physical conditions, every species in each of these groups has, in fact, its own independent history. Neither its geological duration nor its geographical distribution can be deduced from any general law affecting all the species of the class, order, group, or family, or the geological assemblage to which it belongs; each species has, in fact, its own law, because the organic constitution of each stood in a definite and peculiar relation to the conditions in which it was placed.

The study of the Silurian fauna, in its successive stages of development, leads us to recognize in Palæozoic, as in recent times, the important effects of sea currents in transferring to a particular region peculiar sediments and germs of life, first from one area, and afterwards from another,—just as into the Mediterranean, at one time,



is 2·0: now the average distance, from centre to centre, of the districts, is about 18 miles, and the average distance, from centre to centre, of formations about 330 feet. And 18 miles × 3·4 × 5280 = 323136 feet, the horizontal distance of distribution of each species, while 330 × 2·0 = 660 feet, the vertical range of the same, or 1 to 489.

It may perhaps be supposed that all these statements are merely provisional, and liable to be entirely overthrown by additional discovery and the augmentation of numerical data. This, however, is not likely to be the case. The absolute numbers will be altered, but their mutual proportions may probably remain without important variation. In Sir R. I. Murchison's Catalogues, as in ours, the Brachiopoda constitute the most numerous group, and the Wenlock Limestone is the most prolific stratum in the series.

It has been already mentioned that some *species* known or presumed to be distinct, and several *varieties*, are not mentioned in the catalogues (see p. 225). To judge of the degree in which this might affect the numerical *proportions*, the following Table, composed by Mr. Salter, (in June, 1846,) of all the *recognizable forms* in the districts of Woolhope and Abberley, may be consulted.

Species in Abberley, 174; in Woolhope, 256; or 68 to 100. In our tables appear 107, and 143, or 70 to 100; proportions which are but little different.

To give an illustration of the number of Silurian species which are common to more than one district, we may present Mr. Salter's Table, already referred to, of the numerical relation of the fauna of Woolhope to that of Abberley:—

	Species in Woolhope.	Not found in Abberley.	Species in Abberley.	Not found in Woolhope.	Common to both Sections.
Upper Ludlow .	67	33	50	16	34
Aymestry . .	59	46	19	6	13
Lower Ludlow .	14	11	26	23	3
Wenlock Limestone	90	47	66	23	43
Ditto Shale . .	26	23	13	10	3
	256	160	174	78	96

Thus of 334 species only 96 are yet found to be common to these two neighbouring districts.

This result is in harmony with the inferences and deductions obtained on a former occasion.*

* 'Palæozoic Fossils of Devon and Cornwall,' p. 178.—"The chances of occurrence of identical species at different localities in the same range of strata, are much less than is commonly imagined; and in a considerable degree depend on the earnestness and

If we *suppose* that the districts of Abberley and Woolhope do really contain the very same species of organic remains, none being peculiar to either, the number of these species may be obtained by the method of calculation given in the work referred to, viz, 464, a not improbable number.

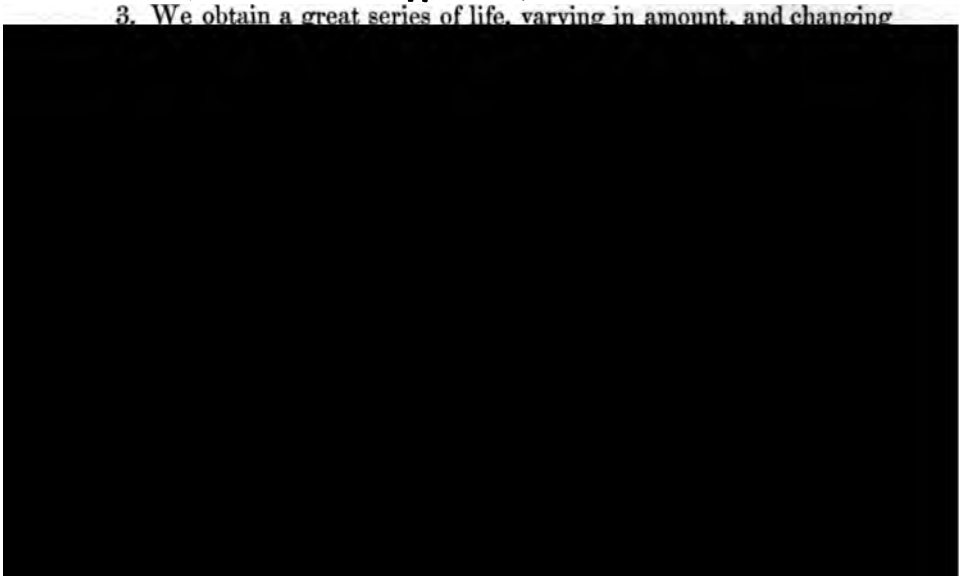
Sir R. Murchison, who gives altogether 351 species of fossils (exclusive of fishes), records 538 geological occurrences of them (or $\frac{I}{K} = 1{\cdot}5$), while for 260 species in our eastern region, we give 535 geological occurrences (or $\frac{I}{K} = 2{\cdot}0$). From this it appears that we have been successful in finding the fossils through a somewhat greater geological range than our predecessor. The difference is not remarkable, but it may be held to indicate the probability that the range of the species is, both geographically and geologically, in reality somewhat more extensive than we at present perceive; but there is no likelihood that a few discoveries of this kind will materially affect the relative aspect of the successive races of the Silurian fauna.

INFERENCES.

1. Though we cannot, on the evidence of fossils gathered in one limited area, and affecting only one period of geological time, *establish* general views of the succession of life on the globe, this is the kind of evidence on which such views must be based, and the inferences to which it leads may be trusted within the limits of the induction.

2. Guided by this principle of interpretation then, we obtain from the organic remains of the Silurian strata, in the regions which have been surveyed, not a record of grand epochal creations and destructions, but a history of successive, more or less gradual, introductions and withdrawals (or additions and suppressions) of life.

3. We obtain a great series of life, varying in amount, and changing



the changes of the elements are, on the great scale, not sudden, sometimes distinctly *gradual*, and sometimes marked by *alternate phases* of greater and less development as to number, and *alternation* or *admixture* of earlier and later races.

5. The dependence of the series of life on physical condition is such, both in respect of the whole number and the specific elements, that these are certainly and definitely related to the mineral character, and circumstances of aggregation of the strata, and frequently even to the peculiar character of certain small parts of the strata; extending as far as these characters reach, and ceasing or verging to cessation when they disappear or decay.

6. The changes of the elementary terms of the series of life are in a certain order of succession; but they are not produced by the transformation of one older species into another newer species, either gradually or by varieties proportioned to the time, or to change of physical conditions.

7. Races are in some cases suddenly lost, and others as suddenly introduced; but the older races occasionally return, and the new species cease for a while; facts all better understood as cases of life supplied by varying currents rather than by local creation.

8. Upon the whole then, *local centres* of life, and *sea currents* varying in direction, appear to be fixed points for the reasoning on the geographical and geological distribution of fossils; as *depth* and *quality of water* is a fixed point for the explanation of their unequal development.

9. To determine the places of these centres of life, and the direction of these currents, is a grand, but does not appear an impracticable problem. Let us, before attempting its solution, collect evidence from the whole series of Palæozoic life, in every part of the British Islands.

List of the Localities in the several Districts which are referred to in the preceding Lists of Fossils, with Notices of the Strata at each place.

1. Cardigan District (*including Fishguard and Lampeter*).

The strata belong to the Lower Llandilo Series, and consist of sandstones, conglomerates, and laminated shales or slates, with graptolites, lingulæ, &c.

Name of Place.	Situation.	Strata.
Abereiddy Bay . .	West of Fishguard . .	L.S. Graptolithic slates.
Crynewydd . . .	Near Cardigan . . .	L.S. Sandstones
Dinas Head . . .	Near Fishguard . . .	L.S. Slate and conglomerate.
Moyl Grove . . .	Near Newport . . .	L.S. Sandstones.
Lampeter		L.S. Slaty series, with annelida.

2. Marloes District (*South of Haverfordwest*).

The strata belong to the Middle (M.S.) and Lower (L.S.) Series of Llandilo.

Name of Place.	Situation.	Strata.
Great Hooton . . .	South of Haverfordwest .	M.S. Sandstone quarries.
Lindsway Bay . .	Near St. Ishmael's (Milford Haven).	M.S. Cliffs of vertical strata.
Marloes Bay . . .	Near the extremity of Pembrokeshire.	M.S. Cliffs of highly inclined or vertical strata, with trap below. (12 Localities).
Musclewick Bay . .	The southern part of St. Bride's Bay.	L.S. Black shales below the trap.
St. Ishmael's . . .	5 miles west of Milford .	M.S. Highly inclined strata; fossil bands; ferruginous
Slate Mill	S.W. of Haverfordwest .	M.S. Highly inclined laminated strata; crinoids entire.
Wooltack Bay . .	The northern part of Marloes Bay.	M.S. Highly inclined strata, with trap below. (3 Localities).

3. Freshwater District (*South of Pembroke*).

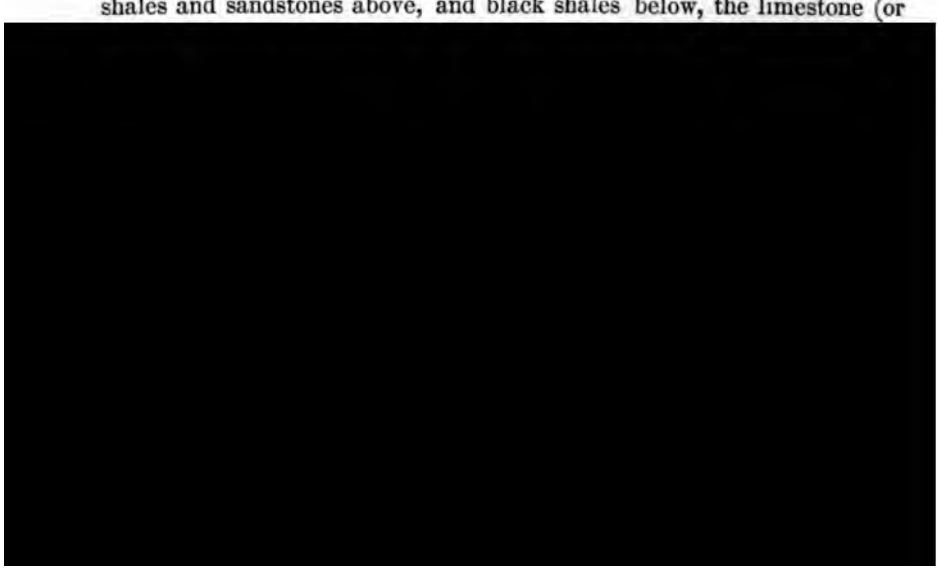
The strata belong to the Middle (M.S.) Series of Llandilo, but only the upper part of it is exposed.

Name of Place.	Situation.	Strata.
Freshwater East Bay	On the north side of the Bay.	M.S. Gray laminated beds; vertical.
	On the south side of the Bay.	M.S. Some calcareous nodules and ferruginous bands in the sandstones.
Freshwater West . .	Ditto	M.S. Some calcareous nodules and bands in the sandstones.
Newton	Near Freshwater West .	M.S. Sandstones.
Throstle Mill . . .	Near Freshwater East .	M.S. Ditto.

4. Haverfordwest District.

a.—(*Near Haverfordwest.*)

The beds consist of the Lower Llandilo Series (L.S.), viz., gray shales and sandstones above, and black shales below, the limestone (or



Name of Place.	Situation.	Strata.
Caerau	2 miles N.E. of Narberth	The limestone series.
Canaston Bridge . .	S.W. of Robeston Wathen	Gray sandstones, &c.
Crinow	East of Narberth . . .	Ditto.
Vaynor Vach (Faynor Vach).	2 m. N.N.W. of Narberth	Limestone series.
Fron	2 miles N.N.E. of Lampeter Velfrey.	The limestone series.
Kiln Park (or Ciln) .	E.N.E. of Narberth . .	Ditto.
Lampeter Velfrey .	3 miles east of Narberth .	Ditto, with black shales.
Lann Mill. . . .	2 miles east of Narberth .	Ditto ditto.
Llandewi Velfrey .	2 m E.N.E. of Narberth	Ditto, with gray beds above.
Narberth . . .	Near the church, and at Stone ditch, close to old red sandstone.	Gray shales.
Penblewin. . . .	North of Narberth . .	Ditto and sandstones.
Penteg	North of Lampeter Velfrey.	Ditto ditto.
Robeston Wathen. .	Near the church, and north of village.	Ditto, limestone, and black shales.

c.—(Near St. Clair's.)*

Cwm	S.W. of Clog y Fran. .	Gray shales (fossils abound).
Clog y Fran . . .	1 mile west of Llandowror	Limestone series (Ogygiæ, &c.)
Great Creswell . . .	2 miles south of St. Clair's	Shales and sandstones (Crinoids, &c.)
Llandowror . . .	2 miles W.S.W. of St. Clair's.	Shales and limestone series (fossils abound).
Maes gwrda . . .	1 mile S E. of Llandowror	Gray shales.
Molden	South of St. Clair's . .	The limestone series.
Moor	Ditto.	Ditto.
Mydrim	3½ miles north of St. Clair's.	Ditto, and slaty beds above and below.
Pant y iar . . .	S.W. of Llandowror . .	Gray shales.
Pant dwfn. . . .	S.E. of St. Clair's . .	The limestone series.
St. Clair's* . . .	Several places near it .	Black shales.
Veynor	Near Llandowror . .	Gray shales.
Walden	Ditto.	Ditto.

5. Carmarthen District.

The strata are of the same age, generally, as in the Haverfordwest District, viz., of the Lower Llandilo Series, but without a clear development of limestone. Conglomerates appear in this district, which is, moreover, affected by trappean admixtures.

Name of Place.	Situation.	Strata.
Abergwili	2 miles East of Carmarthen.	Slaty and trappean beds.
Bwlch Capel . . .	3 miles N.N.W. of Carmarthen.	Slates, with Graptolites.
Castell y Waun . .	3 miles E. N. E. of St. Clair's.	Shaly beds, with Dalmannia caudata; dip North.
Gallt Merddyn . .	East of Abergwili . .	Sandstones.
Lett yr Hendref . .	N.E. of Abergwili . .	Slaty beds, with Catenipora.

* On the Ordnance Map St. Clare's; written St. Clears sometimes.

Name of Place.	Situation.	Strata.
Near Llanllwch . .	West of Llanllwch . .	Orbicula in black shales.
Melin Ricket . . .	5 miles W.N.W. of Carmarthen.	Slaty beds.
Mount Pleasant . .	South of Carmarthen .	Sandstones.

6. Llandilo District.

a.—(*North of the River Towy.*)

The strata are all of the Lower Llandilo Series, *i.e.*, limestone and flags, with shales, and dipping generally North.

Name of Place.	Situation.	Strata.
Aberglasney . . .	3 miles West of Llandilo	Limestone in several bands.
Bird's Hill Quarry .	N.W. of Dynevor Park	Limestone Series.
Crug (Grug) . . .	Ditto	Limestone. Large Trilobites.
Cwm y Gerwyn . .	North of Llandilo . .	Slaty beds over limestone.
Drwsllwyn . . .	5 miles West of Llandilo.	Limestone Series.
Dynevor Park . .	Many places in the Park	Ditto.
Dynevor Park Mill .		Ditto.
Glandwr	West of Dynevor Park .	Ditto.
Lletty meilog . . .	2 miles North of Llandilo	Shaly beds, dip North (Dalmannia).
Llwych gwyn. . .	Near Pont ar Cothi . .	Limestone Series.
Llandilo	Several places about the town.	Limestone and flaggy shales.
Nant y rhibo . . .	North of Llandilo . .	Beds over the limestone.
Pen yr allt fawr . .	2 miles West of Pont ar Cothi.	Limestone Series.
Taliaris	4 miles N.N.E. of Llandilo.	Sandstones.
Ty Picca	West of Llandilo . . .	Limestone.
Wern ddu	6 miles West of Llandilo	Slaty beds.
Llangwm	North of Dynevor Park .	Flaggy Series.

b.—(*South of the River Towy, and West of the River Sowdde, or Sawdde*).

The strata comprise the complete Series of South Wales, from the Tilestone with Fossils, to and including the Llandilo Limestone Group.

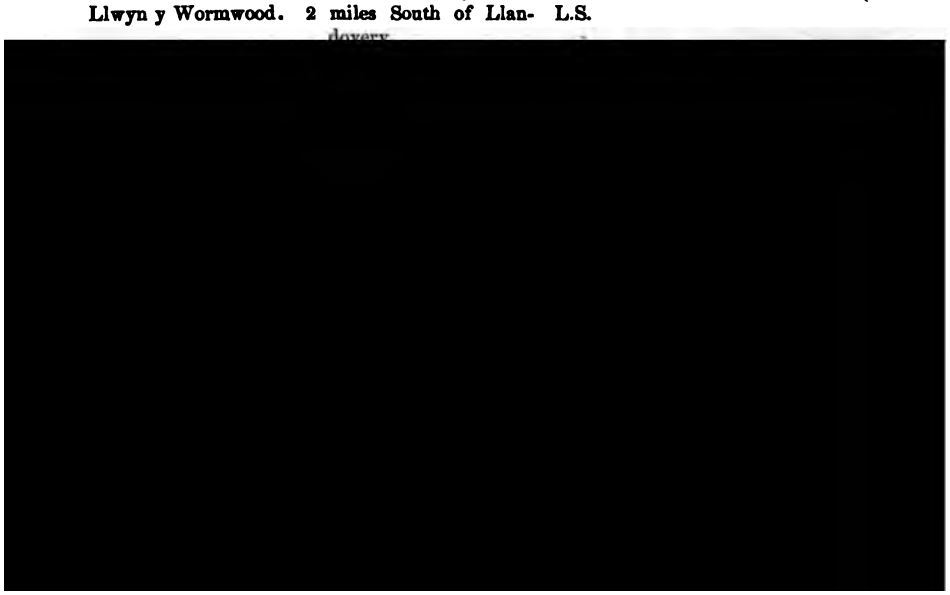
Name of Place.	Situation.	Strata.
Coed Sion	1 mile N.N.W. of Pont ar y llechau.	L.S. Shales and flags over Limestone Series.
Cwm ddu	3½ miles East of Llandilo	L.S. Shales and subcalcareous beds.
Carn goch. . . .	4 miles East of Llandilo	L.S. Sandstone in an anticlinal (corals in the rock).
Carreg llwydd . .	Ditto.	M.S Shales and Sandstones.
Cae yn y Coed . .		
Dafaddfa Uchaf South	1 mile S.W. of Trichrug Mountain.	T.S. Gray fossiliferous shales and sandstones, with old red beds below.
Ditto North	Ditto.	M.S. Purple beds, with Orthonotæ, &c.; may be regarded as of the Myddelton Series (=Upper Ludlow).
Glandwr	2 miles West of Llandilo	L.S. Limestone Series.
Gwaun hir . . .	2 miles East of Llandilo	L.S. Flaggy shales.
Golden Grove . .	1. Quarry West of the House.	L.S. The Limestone Series.
	2. In road to Bryn bach .	M.S. Sandstone quarries.
	3. Higher in the same road.	M.S. Shaly sandstones in road.
	4. Great quarry at Bryn bach.	M.S. Shaly sandstones near the top of this series (Upper Ludlow).
Golden Grove . .	Near Keeper's Lodge, and East of the House.	L.S. & M.S. Shales with Leptæna serlicea, &c., which may be regarded as the base of the Myddelton Series (Wenlock Shale), passing into the flaggy shales which cover the Llandilo Limestone (see vol. 1, p. 24).
Gwern y llyn . .		
Llwych gwyn. . .		
Llwyn y Maendy. .	3 miles N.E. of Llandilo	L.S. Limestone Series.
Maerdy bach . . .	1 mile South of Llandilo	L.S. Limestone Series of Golden Grove.
Myddelton or Middleton Hall.	South of Llanarthney .	M.S. Here, near Ty coch, the Myddelton (=Ludlow and Wenlock) Series comes out from under the overlying old red, and widens eastward.
Nant Hirion . . .	South of Llandilo . .	L.S. Limestone Series.
Nelson's Tower Wood	S.S.E. of Llanarthney .	M.S. The whole series between the hill-top and Llanarthney.
Pont Ladies . . .	South of Llandilo . .	L.S. Low part of the Llandilo Flag Series, with sandstone of considerable thickness.
Pontbrennareth . .	3 miles N.E. of Llandilo	L.S. Limestone Series.
Penllwynan . . .		
Pen y goylan . . .	3 miles S.W. of Llangadoc	L.S. The Llandilo Flags, dug.
Pwll-llacca . . .	1½ mile East of Llandilo.	L.S. Black shales with graptolites.
Pont ar y llechau. .	3 miles S.S.E. of Llangadoc (on the Sawdde).	T.S. & M.S. Here the limestone (with a great thickness of old red below) is very fossiliferous. The Myddelton (=Ludlow and Wenlock) Group is cut through by the Sawdde.
Rhiw goch . . .	East of Nelson's Tower .	M.S.
Ty gwyn	East of Llandilo . . .	L.S. The Limestone Series.

Name of Place.	Situation.	Strata.
Trichrug	3½ miles South of Llangadoc.	T.S. and M.S. well shown. Thick old red beds below T.S.
Tregib.	S.E. of Llandilo . . .	L.S. Limestone Series.
Storm Hill Lodge .	2 miles South of Llandilo	T.S. Here the Tilestone has some old red below it.
Swansea Road . .	By Golden Grove Park .	T.S. & M.S. The sections in this road give excellent opportunities of studying the Tilestone and Myddelton Groups.
Ysgubor wen . . .	1 mile East of Llandilo .	L.S. Llandilo Flag Series.

c.—(East of the River Sowdde, including Districts about Llangadoc, Llandovery, and Noeth Grug).

The beds are of the Llandilo, Myddelton, and Tilestone groups, the lower group being almost deficient of limestone, and much mixed with sandstones and conglomerates.

Name of Place.	Situation.	Strata.	
Bwlch Trebannau .	N.W. of Llandovery . .	L.S.	Conglomerate, corals and shells.
Castell Meyrigg . .	S. of Llangadoc . . .	L.S.	Flaggy and calcareous.
Cefn Llwydlo. . .	N. of Llandovery. . .	L.S.	
Cefn Rhyddan . .	2 miles S.S.W. of Llandovery.	L.S.	Vertical flags, Atrypa crassa.
Cefn y Garreg . .	2 miles South of Llandovery.	L.S.	Ditto.
Cwmbran	3 miles East of Llangadoc	M.S.	
Carreg llwyd . . .	2½ miles S.W. of Llandovery.	L.S.	Quarries.
Goleugoed. . . .	3 miles S.W. of Llandovery.	L.S.	Calcareous mudstone quarries over the conglomerate.
Gilfach	3½ miles East of Llangadoc	M.S.	(Old Mine).
Gorllwyn	West of Myddfai . . .	M.S.	
Glas allt fach . . .	3½ miles S.W. of Llandovery.	L.S.	Quarried edges.
Garnllwyd . . .	East of Myddfai . . .	M.S.	
Llechclawdd . . .	2 miles S.E. of Myddfai .	T.S.	Micaceous beds.
Llwyn y Wormwood.	2 miles South of Llandovery	L.S.	



7. Builth District (*including Corn y Fan*).

The strata correspond sufficiently to the type of the eastern regions to be marked by the same letters.

Name of Place.	Situation.	Strata.
Aberedw	2¼ miles E. of Builth .	U.L. A.L. L.L. Mudstone, and thin limestones.
Blaenau		U.L. Mudstone.
Builth	The Bridge, &c. . . .	W.S. L.S. Black shales, Graptolites.
Cwm Craig ddu . .	6 miles S.W. by W. of Builth.	U.L. A.L. L.L. W. Sandy and argillaccous beds.
Carneddau . . .	Builth Hill	L.S. Hard flags and trappean beds.
Gilvern Head . .		L.S.
Erw Gilfach . . .	Old Brecon road . . .	W.L.? Sandy beds; Terebr. navicula abundant.
Henllyn Hill . . .	6 miles S.E. of Builth .	U.L. Dark flaggy mudstones.
Neuadd Llwyd . .	2 miles E. of Builth . .	W.S. Graptolites and Orthoceratite flags.
Pengarreg. . . .		U.L.
Pencerrig	2 miles N. of Builth . .	L.S. Quarry at house. Thin limestone and flags.
Pwll ddu		U.L.
Tan y Graig . . .	1 mile N. of the town .	L.S. Volcanic grits, fossiliferous.

Usk District.

Beech Hill . . .	N. of Usk	U.L. Crest of the hill.
Bryn Graig . . .	3 miles W.N.W. of Usk .	W.S. Sandstone and shale.
Cilfigan	1½ mile W. of Usk . .	W.L. Old quarries in field.
Cilorgyr	3 miles S.W. of Usk . .	W.L. Quarries.
Cock Wood . . .	N. of Usk	U.L. Edge of hill.
Coed y Pan . . .	N E. of the Darran . .	L.L. Quarry under the house.
Castle Barn . . .	N. of Usk	U.L. Edge of hill.
Cefn Ila	1 mile W. of Usk. . .	W.L. Quarries.
Cefn Ila Lodge . .	Ditto	L.L. Road cutting.
Craig y Garcyd . .	2 miles N.W. of Usk . .	W.S. Wood by the river.
Darran	3 miles S.W. of Usk . .	U.L. West side of the brook.
Dowlas	1 mile S.W. of Usk . .	L.L. W.L. Quarries and fields.
Glascoed	2¼ miles W. of Usk . .	W.L. W.S. Quarries and fields.
Hill Barn	1½ mile N. of Usk . .	U.L. Road down the hill.
Llanbadoc . . .	S. of Usk	U.L. A.L. A good section.
Llangibby. . . .	2 miles S.S.W. of Usk .	U.L. A.L. West of castle, in road.
Lancayo	1 mile N. of Usk . . .	A.L. Quarries.
Prescoed Common .	2½ miles W.S.W. of Usk.	W.L. W.S. Quarries and fields.
Radyr Mill . . .	1 mile N.W. of Usk . .	W.S. Shales in cliff.
Radyr Hill . . .	1 mile N.W. of Usk . .	W.S. Sandstone beds.
—— Lime-quarries	Ditto	W.L. Great quarries.
Radyr, South of . .	At Coed dduon . . .	U.L. Excavation in fields.
Radyr, South-east of.	Ditto	U.L. Ditto.
Russell's Farm . .	1 mile E. of Trostrey .	A.L. In lane.
Ty Newydd . . .	3 miles N.W. of Usk. .	W.L. Great quarries.
Ty Goch	4 miles on Brecon road .	U.L.?
Trostra, or Trostrey .	2¾ miles N.N.W. of Usk.	W.L. W.S. Quarries and cliff under.
Tucking Mill . . .	2 miles N.W. of Usk .	W.S. Lowest beds in district.

Name of Place.	Situation.	Strata.
Usk Castle . . .	At Usk	U.L. Road cuttings.
Usk, North of . .	Near the river . . .	L.L. Road cuttings.
Ysgubor Gwynt . .	½ mile N. Llangibby Castle	L.L. Deep cut in lane

Tortworth District.

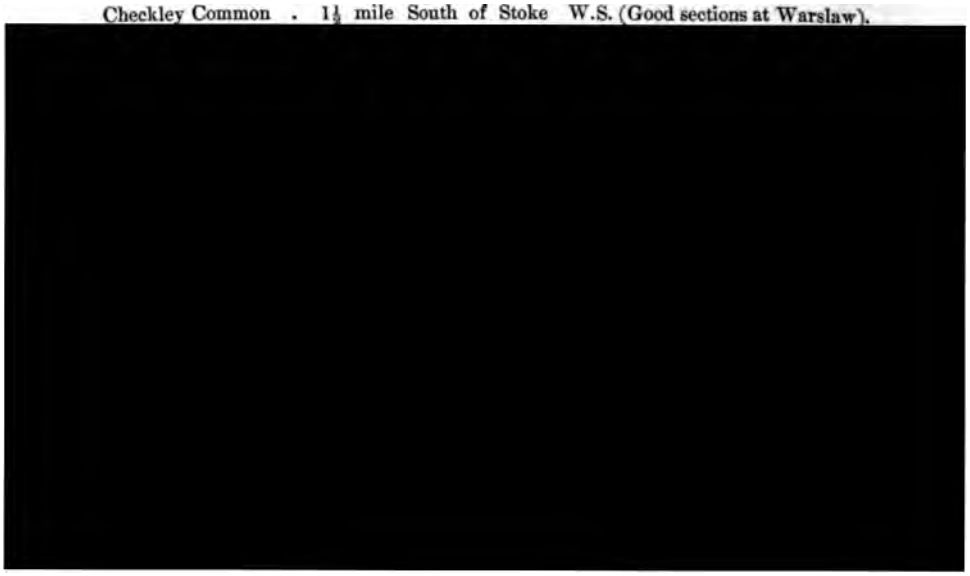
Charfield, Long's Quarry.	S.E. of Tortworth . .	U.C. Laminated beds.
Charfield, Skeay's Quarry.	Ditto	U.C. Ditto.
Falfield	West of Tortworth . .	W.L. Limestone quarries.
Horseshoe Farm . .	1 mile West of Cromhall	? Sandstones cut through in road.
Pyrton Passage . .	On the Severn North of Berkeley.	U.L. W.L. Beds exposed on the South side of Severn (p 191).
Stone	2½ miles South of Berkeley	U.C. Laminated beds.
Whitfield	1½ mile N.W. of Cromhall	W.L. Limestone quarries.
Woodford Green . .	2 miles South of Berkeley	U.C. Laminated beds.

May Hill District.

Hobbs, South of . .	S.E of Longhope . . .	U.L. Laminated shales.
Huntley Hill . . .	West of Huntley . . .	U.C. Laminated sandstone.
May Hill	The centre of the District	U.C. Thick and thin beds of sandstone
—— S.E. of . . .	Near Huntley. . . .	U.C. Laminated sandstone.
Rock	A farm East of Longhope	W.L. Limestone quarries.
—— West of . . .	Ditto	W.L. Ditto.
—— South of . . .	Ditto	W.S. Soft shales.
Between Rock Farm and Dursley Cross.	Ditto	W.S. Ditto.
Taynton, North of .	1½ mile North of Huntley	U.L. Laminated beds (reddened).

Woolhope District.

Backbury Hill . .	N.E. of Mordiford . .	A.L. Great land-slips.
Bodenham . . .	S.W. of Much Marcle .	U.L. A.K. (Pentamerus Knightii).
Cockshoot	West of Putley . . .	A.L. (Remarkable joints.)
Canwood, E. and W. of it.	North of Woolhope . .	W.L. Ranges of quarries.
Checkley Common .	1½ mile South of Stoke	W.S. (Good sections at Warslaw).



Name of Place.	Situation.	Strata.
Putley.	4 miles due West of Ledbury.	U.L. Quarries.
Perton.	West of Stoke Edith . .	U.L. Top of Upper Ludlow.
Prior's Court and P. Farm.	Between Mordiford and Stoke Edith.	U.L. Large quarries.
Queen's Wood . .	Near Newent	W.L. In large quarries.
Stoke Edith . . .	On the North side of the District.	U.L. Exposed in roads. Park.
Sutton, Old . . .	North of Mordiford . .	U.L. Large excav. Many fossils.
Shucknall Farm . .	South end of the Hill. .	U.L. Many fossils.
—— Hill	Great Quarries . . .	U.L. A.L. Remarkable joints.
Winslow Mill. . .	E.N.E. of Woolhope . .	W.L. Old quarries.
Wootton Farm . .	West of Dormington Wood	L.L. Beds faulted and slipped.
Wonder	S.W. of Putley . .	U.L. Great land-slip.
Welsh Court . . .	Near Bodenham . .	U.L. The series well seen.
Woolhope. . . .	The Village in centre of District.	W.S. WP.L. Good sections.
—— South of . .	(At Twillis)	WP.L. Ditto.

Abberley District.

Ankerdine Hill . .	South end of District . .	U.L. A.L. U C. (see p. 149).
Abberley (Lodge) .	N.W. end of District (at the Teme).	W.L. Large quarries.
Barrell Hill . . .	S.W. of Woodbury Hill, near Hole Farm.	U.L. Junction with Old Red.
Callow Farm . . .	North of Martley. . .	W.L. Great quarries.
Collins' Green . .	North of Ankerdine Hill.	W.L. Quarry.
Fetlock's Farm . .	2 miles North of Martley	W.L. (See p. 147).
Hill end, and East of it	N. and N.W. of Martley	U.L. A.L. L.L. W.L. (See p. 151).
Hole Farm . . .	S.W. of Woodbury . .	U.L. L.L. (The A.L. is also seen).
Martley, Road W. of	7 miles N.W. of Gloucester	L.L. Beds undulated,
Ridgehill Farm . .	N.N.W. of Martley . .	A.L. (Dip East.)
Tinker's Copse . .	North of Ankerdine Hill.	W.L. W.S. Quarry
Walgrove Hill . .	South of Abberley Lodge	U.L. A.L. (See p. 153).

Malvern District.

Alfrick	In the Northern part of the District.	WP.L. is seen West of it.
—— Pound . . .	S.W. of Alfrick . . .	W.S. U.C. In road cuttings.
Bason Court Farm .	1¼ mile W.N.W. of Alfrick	A.L. (The ridge West of Farm).
Brand's Lodge . .	N.W. of Little Malvern .	WP.L. In road.
Brock Hill and Section to Wych.	West of the Wych . .	D.S. U.L A.L. L.L. W.L. W.S. U.C. (See p. 97).
Birchwood Common .	Hill, South of Old Storridge Hill.	U.C. Coarse and conglomeritic.
Birchen Hall . . .	S.S.E. of Alfrick . . .	W.S. Gray shales.
Crumpend. . . .	N.N.W. of Malvern Hills	W.S. WP.L. Quarry and roads.
Colwall Copse . .	On the Brock Hill Section	W.L. Pisolitic limestone.
Croft Farm . . .	West of Great Malvern .	W.L. W.S. Great quarries.
Cowley Park . . .	North end of Malvern Hills	L.C. In vertical strata.
Crew's Hill . . .	Near Alfrick	WP.L. In road cuttings.
Chance's Pitch . .	In road from Malvern to Ledbury.	A.L. In long excavations.

Name of Place.	Situation.	Strata.
Conygre Wood . .	Near Ledbury . . .	W.L. Several bands of limestone.
Clincher's Mill . .	South of Eastnor . . .	W.L. Great quarries (p. 79).
Coomb Hill . . .	West of Colwall . . .	U.L. A.L. Ditto.
Dog Hill	N.E. of Ledbury . . .	L.L. Road cuttings.
Evendine	Between Little Malvern and Colwall.	A.L. Well exhibited.
Eastnor Park, and Castle.	East of Ledbury . . .	W.L. Many excavations.
Eastnor, South of. .	By road-side	L.L. Slight excavations.
Fair Oaks	2 miles South of Little Malvern.	U.C. Ditto.
Gunwick Mill . .	Valley N.W. of Old Storridge Hill.	U.C. On the anticlinal arch.
Gold Hill	South of Eastnor Castle .	W.L. In fields and quarries.
Holywell (Turnpike)	2½ miles W.N.W. of Great Malvern.	W.L. Great quarries.
Halesend	3 miles N.W. of Great Malvern.	U.L. A.L. Ditto (see p. 94).
Hall Court . . .	W.S.W. of Great Malvern	U.L. From under Old Red.
Hereford Beacon, near	West side of the Hill . .	W.L. Old quarries.
Hayclose Wood . .	Near Clincher's Mill. .	WP.L. In fields.
Howler's Heath . .	Near South end of District	U.C. L.C. In roads and quarries.
Hope End	S.W. of Colwall . . .	A.L. In undulated ridges.
Mathon Lodge . .	S.W. of Great Malvern .	U.L. Quarry West of Lodge. W.L. Quarry North of Lodge.
Obelisk	In Eastnor Park . . .	L.C. In road cuttings (p. 59).
Overley	2½ miles West of Great Malvern.	U.L. Junction with Old Red.
Old Castle. . . .	West of Little Malvern .	U.L. Ditto.
Pound	N.W. of Colwall . . .	U.L. Quarry, very rich.
Raffnal Wood . .	2½ miles West of Ledbury	U.L. Anticlinal axis.
Rilbury Camp . .	N.E. of Ledbury . . .	A.L. Ditto.
Swinyard Hill . .	S.S.W. of Little Malvern.	WP.L. U.C. In the pass at North end of hill.
Stump Wood . . .	In Eastnor Park . . .	WP.L. Great quarry.
Stonesway . . .	S.W. of the Wych . .	U C. Laminated beds.
Storridge, Farm . .	2¼ N.W. of Great Malvern	WP.L. W.S. Quarry and roads.
Walm's Well . . .	Road from Eastnor Park	WP.L. Road cutting (see p. 71).

PALÆONTOLOGICAL APPENDIX

To Professor John Phillips' Memoir on the Malvern Hills, compared with the Palæozoic Districts of Abberley, &c. By JOHN PHILLIPS, F.R.S., and JOHN WILLIAM SALTER, A.L.S., F.G.S.

In the following notes, such species of invertebrata as appeared to be undescribed, or to require additional illustration from a more perfect knowledge of their structure, are introduced. The latter are by no means unimportant; for, from the state of preservation in which the Silurian fossils are usually found, the first notices of them have been frequently imperfect. The aid of a larger series of specimens collected by the Geological Survey has enabled us to render their history more complete, and to compare them with species published in continental works since the appearance of the 'Silurian System.' The result of this examination has been rather to identify our British species with those of Northern Europe and of America, than to afford any great amount of novelties. The species herein described have the initials of the respective authors attached.

ANNELIDA (CEPHALOBRANCHIATA?).

TRACHYDERMA, New Genus, Phillips.

The only part remaining of this group being the external case or tube (analogous to the "shell" of Serpula and Spirorbis), truly generic characters cannot be assigned; for these must depend on parts of the organization of higher physiological value than the dermal secretion. The structure of the covering is, in the arrangement of the incremental lines and rings, more analogous to that of the Serpulidæ than to what occurs on other groups of Annelida, or on the fistuliform Radiaria and Ascidiæ. It may, in fact, be pretty exactly paralleled on large specimens of Serpulidæ.

Until this systematic structure was recognized, the true place of this genus in the animal kingdom was regarded as doubtful. By it we are conducted to the inference that it may be ranked among Serpulidæ, having a membranous covering, and a remarkable, though not quite regular, alternation (due, perhaps, to a peculiar spirality) of the successive laminæ of growth. There are, however, some appearances in the specimens of *T. coriacea*, which may possibly be adduced in favour of a reference of this fossil to a different group of Annelida.

TRACHYDERMA CORIACEA, Phillips.

REF.—Plate IV., fig. 1, 2.

SPECIFIC CHARACTER.—Tube elongated, flexuous (originally membranaceous), transversely annulated with numerous very approximate sharp

plaits, which, by alternate approach and separation along certain bands parallel to the axis, give an appearance of sides to the tube. Along these sides, for a certain length, the rings appear protuberant or tubercled. One extremity is much smoother (and less bent) than the other.

Locality.—In the Upper Ludlow beds of the Abberley Hills.

Remarks.—The tube is pressed flat between the laminæ of fine silt which compose the stone, and retain the impression of this elegant fossil. Its colour is brown. The length is about ten times the diameter of the flattened tube (perhaps fifteen times that of the originally cylindrical body); the width is greatest in the middle portion, and the tapering is gradual, especially toward the smoother extremity. The rings, though in a general sense transverse to the axis of the tube, are undulated by forward and retral curves; and these are so arranged, that very *frequently* the forward curves of one are succeeded on certain longitudinal bands by the retral curves of the next, as shown in fig. 2 *a*. In several cases there appear two forward and two retral curves to each ring; but many irregularities occur to spoil the apparent symmetry of this arrangement. A few elevated and irregular striæ intervene between the rings. The smoother part of the tube shows the same mode of arrangement of the successive incremental rings, but their projection is less. There is some appearance of lateral enlargement for a portion of the length of the body, as if the segments were there setigerous or tuberculated. If this should be found correct, the place of the fossil among Serpulidæ might be doubted.

No other fossils appear in the thin silty deposit which encloses these remains.—J. P.

Trachyderma squamosa, Phillips.

Ref.—Plate IV., fig. 3, 4.

Specific character.—Tube elongated, flexuous (originally membranaceous), transversely annulated with numerous elevated plaits, which approach to and recede from each other, and sometimes unite, and rise at irregular distances into short cariniform projections, or small rugosities.

Locality.—In the Upper Ludlow beds at Gomley, near Newent, &c.

occasionally prominent, striations, apparently lines of growth. In one specimen (a fragment figured f. 4), these striations constitute nearly all the markings on an otherwise almost smooth surface.

In the gray unevenly laminated sandstone which encloses the specimens, we recognize evidence of very shallow water, with a bottom of silt or fine mud. Many small inequalities in it are probably due to fucoids.—J. P.

SERPULITES, Murchison.

A name provisionally applied to the shelly tubes frequently met with in Silurian rocks. It is, of course, only intended, as is usual with obscure fossils, to mark its relation to the commonest genus of the tribe, *Serpula*.

S. CURTUS, Salter.

REF.—Pl. XXIX., fig. 1, 2.

SPECIFIC CHARACTER.—A nearly round, free, rapidly tapering, curved [sinistrally], shelly tube.

The curve of the shell is wide, and a little spiral sinistrally, but this latter character may not be constant; the section is round, a little flattened above. Lines of growth, moderately strong and oblique, occur on a part of the shell; but it is somewhat crystalline, and they cannot be trusted as true lines of growth. We have but two specimens, both figured, from—

Locality.—Collins' Green, Abberley (in Wenlock Shale nodules).—

J. W. S.

CRUSTACEA. [By J. W. S.]

TRIBE PALÆADÆ. Family TRILOBITÆ. *Burm.*

As there has been much lately done to illustrate the anatomy of the Trilobites, the accompanying wood-cut may be useful, as indicating the portions described under each particular genus or species. This nomenclature, begun by Dalman, enlarged by Pander and Zenker, has latterly been reviewed and applied by Burmeister, from exact comparison with the living relations of the tribe. Some few additions seem necessary for the purpose of description; these are inserted.

Burmeister, in his late valuable work on the affinities and structure of Trilobites, assigns them the above rank: considering the *Palæadæ*, in which he includes the families *Cytherinidæ*, *Eurypteridæ*, and *Trilobitæ*, of equal rank with the *Phyllopoda*, and very nearly related to them. The above denomination renders the subdivisions into *Calymenæ*, *Asaphi*, *Ogygiæ*, &c., sectional, not family groups.

I adopt, however, the order of Emmerich's groups as the most natural yet published; Burmeister's primary division into those capable and those incapable of rolling up, being based upon an erroneous assumption,* necessarily vitiates his arrangement.

* It is true that flat species, and especially those which have their fulcral point near the end of the pleuræ, can only double up, not roll into a ball; but this is a [illegible] variation.

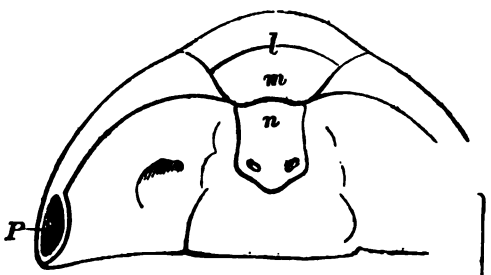


Fig. 1.

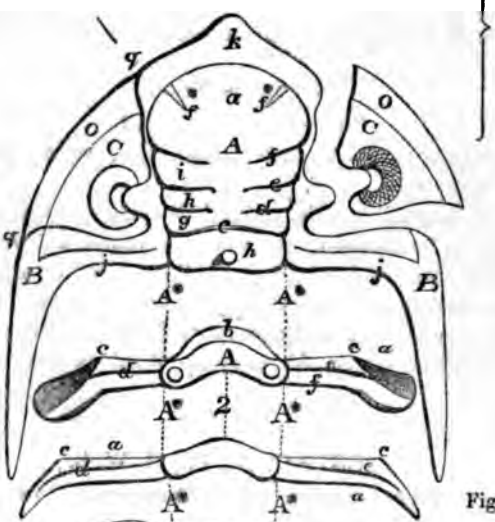


Fig. 2.

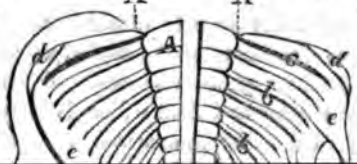


Fig. 3.

Since these descriptions were ready for press, we have received Hawle and Corda's work on the Bohemian Trilobites; containing descriptions of a large number of new genera. Whether our knowledge of the subject justifies this minute division of the tribe will be decided by entomologists. We can only indicate the genera, where they apply to the forms here described. It must be confessed, that the parts of the mouth are well preserved in the Bohemian specimens, so as to enable the authors to connect the variations of the hypostoma (labrum?) with those of the glabella, and other parts of the head. I would however say, that as far as my experience goes, the suppression of a pair of furrows in an inflated glabella, an extra body-ring in certain groups, and the possession or want of spines behind the head in some cases, are not, of themselves, sufficient reasons for instituting a new genus; *Proetus* certainly includes variations of the first, *Illænus* the second, and *Cybele* examples of the last variation; and, as a general rule, it would seem that an interchange in a third species of the component characters of two apparently distinct forms should lead us to conclude them all of one genus, rather than consider the last found as an intermediate generic form. In the work in question, *Actinopeltis* and *Eccoptochile* are separated from Beyrich's well-marked genus *Cheirurus*; the first by the want of upper furrows and of one body segment, the latter has an additional body segment, and a slightly different form of *hypostoma:* the habit in all three is very similar. *Tetrapsellium* is distinguished from *Trinucleus* solely by a swelling in the axal furrows of the head; it is almost identical else with *T. seticornis;* other points of this kind will be noticed in the descriptions. The figures of the smaller and as yet unknown Trilobites will be very useful, and fill up gaps in the series.

Section PHACOPS (Trilobites with facetted eyes. *Emmerich*).*

PHACOPS, Emmr.

P. STOKESII, Milne Edw., sp.

REF.—Pl. V., fig. 1, 1*a*.

SYNONYMS.—*Calymene macrophthalma.* Brongn. Crust. foss. pl. 1, f. 5; Murchison, Sil. Syst. t. 14, f. 2; Buckland's Bridgewater Treat., pl. 46, f. 4 (not 5); *P. Stokesii*, Milne Edw. Crust. v. 3, 324.

SPECIFIC CHARACTER.—Finely granulated; glabella an equilateral spherical triangle covered with fine tubercles, inflated, overhanging the front, with a basal lobe only, which forms a small tubercle on each side; eyes very large, broadest behind, of numerous close-set lenses; pleuræ with a shallow straight furrow; tail semicircular, flattish, the axis of five convex ribs, contracted and depressed below, about half as wide as the side lobe, which has four or five shallow impressed lines.

The species under consideration has been sadly confused, first by the union of two distinct forms by Brongniart, then by Murchison's assigning Brongniart's typical form to the new species, *C. Downingiæ;* Milne Edwards separated

* The characters of these families or sections are given in the 4th vol. of Scientif. Memoirs, translated from Leonhard's 'Neues Jahrbuch,' 1845, pt. 1.

ours by the above name, retaining *macrophthalma* and *Downingiæ*, in which view I agree. Portlock altered the original name, and Burmeister has united the American species *C. bufo*, and the continental *C. latifrons*, to Brongniart's fig. 5. As we have not seen specimens of *C. latifrons*, we can only judge from Brongniart's figure; and the shape of the animal, and the coarse tubercles, seem to agree very well with authentic specimens of *P. bufo* of American authors, in Mr. Lyell's collection. But between the latter and our English species of which we only have one or two good specimens, are considerable differences; nor do the English specimens yet observed at all approach it in dimensions, or rough sculpture.

The glabella of *P. bufo* is a right-angled triangle, and more depressed; the eyes broadest forward, of few and distant lenses, and the tail regularly convex, with about eight arched ribs on the axis (instead of five as on the flattened tail of *P. Stokesii*); and there are several proportional differences in the head, eyelid, pleuræ, and especially the granulation, which is very large and coarse, while in our species it is fine and scarcely tubercular.

If these distinctions be admitted, the dispute, as far as our Wenlock species is concerned, will terminate.

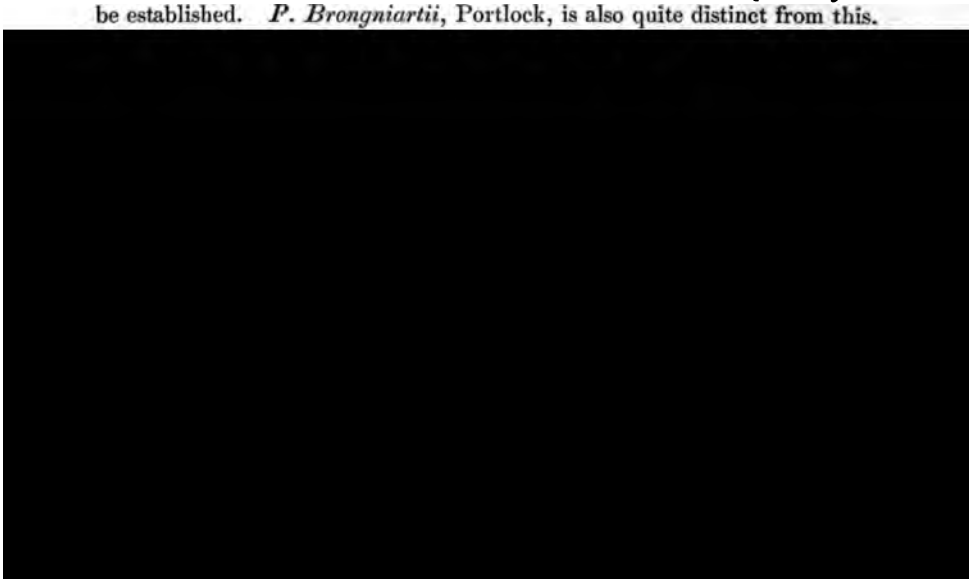
Locality, fig. 1.—Wall Hills; also in Caradoc shale of Gunwick Mill, and shales of Llanddewi, Radnorshire.

P. Downingiæ, Murch., sp.

Ref.—Pl. V., fig. 2, 3, 4.

Synonyms.—*Calym. Downingiæ*, Murch. Sil. Syst. t. 14, f. 3; Milne Edw. Crust. v. 3, 324; *C. macrophthalma*, Buckl. Bridgw. Treat. t. 46, f. 5; *Phacops Downingiæ*, Emmr. in Neues Jahrb. 1845, pt. 1 [transl. in Scientific Memoirs, vol. 4, pl. 4, f. 2, icon mala.]

We have given the real synonyms, and a figure of the internal cast of the head and tail of this elegant animal, to show how distinct the species is from Brongniart's fig. 4, with which it has been so often confounded. Emmerich, however, and Milne Edwards admit the differences, and it will probably now be established. *P. Brongniartii*, Portlock, is also quite distinct from this.



The genus seems a natural one, though no doubt some species are intermediate in character. *Odontochile*, Hawle and Corda, appears identical with this genus.

D. AFFINIS, Salter.

REF.—Pl. V., fig. 5.

SPECIFIC CHARACTER.—Caudal shield broad, with 15 or 16 furrows on the lateral lobes, reaching nearly to the narrow margin; axis nearly as broad as the lateral lobe, not convex, reaching to the posterior fifth; end of tail truncate (emarginate ?).

This offers much resemblance to the interesting Irish species *Phacops truncato-caudatus*, Portl., and is evidently a near relation; yet the great breadth of the axis is quite sufficient to mark it: the furrows on the side lobes are more numerous and longer. Both species occur in Westmoreland, and have been described for Prof. Sedgwick's work on that district.

Locality.—Llandowror.

PROETUS, Steininger; Lovën.

ÆONIA, Burm.; FORBESIA, M'Coy.

A very usual character of this genus is the possession of a strong tubercle, terminating the neck segment on each side, and nearly separated from it. Burmeister, however, in his second edition, has considered the species having this thickening, and the obscure glabella furrows more strongly marked, as forming a distinct genus, which he calls *Æonia*. M'Coy had anticipated him by a few months in the name *Forbesia*, without referring to *Proetus*. We prefer, with Lovën, to consider both as belonging to one genus.

The glabella shows two or three lateral furrows, but is sometimes quite smooth. Body rings 10. The tail has but few lateral furrows, seldom more than 7 or 8; and in this, as well as in the additional body segment, the Silurian genus differs from the carboniferous *Phillipsia* and *Griffithides*, which are else very nearly related to it.

P. LATIFRONS, M'Coy, sp.

REF.—Pl. VI., fig. 1.

SYNONYMS.—*Forbesia latifrons*, M'Coy, Sil. Foss. of Ireland, pl. 4, f. 11.

SPECIFIC CHARACTER.—Oval; width three-fifths the length; gently convex; head and body equally long; axis prominent, rather narrow; glabella smooth, widest and most convex behind, as wide as the cheeks, not reaching to the tumid margin; eyes close to it, large, not prominent; facial suture vertical from the eye till close to the neck margin, then turning abruptly outwards to the first third; spines thick, vertical, reaching the fourth or fifth segment; axis of body narrow and prominent; fulcrum at half its front, one-third behind; caudal axis six or seven-ribbed, prominent, [illegible] only four-fifths the length of the semicircular shield, and narrow[illegible],

which have about five furrows not reaching the border, with faint ones between them.

Very near to *P.* (*Calymene*) *Rowii*, Green, of which the cast has been published; but that species is very convex, the axis is wider, that of the tail more conical, and the sides also of the tail are about nine-ribbed.

We have seen Mr. M^{c}Coy's specimen, which is somewhat shortened in all parts by pressure; it is, however, the same species. His description is full and lucid; but he mentions and figures too many furrows on the tail, and one too many segments to the body—there are only 10.

Locality.—Upper Ludlow Rock of Usk.

Section Asaphi, *Emmr.*

Divided into genuine *Asaphi* and *Ogygiæ*, or contractile and non-contractile species. *Asaphus* and *Illænus* belong to the first section.

Illænus, Dalm.

The body-rings vary in number, 9 or 10, if we exclude *Nileus*, Dalm., which has only 8. It is highly probable it ought to be included.

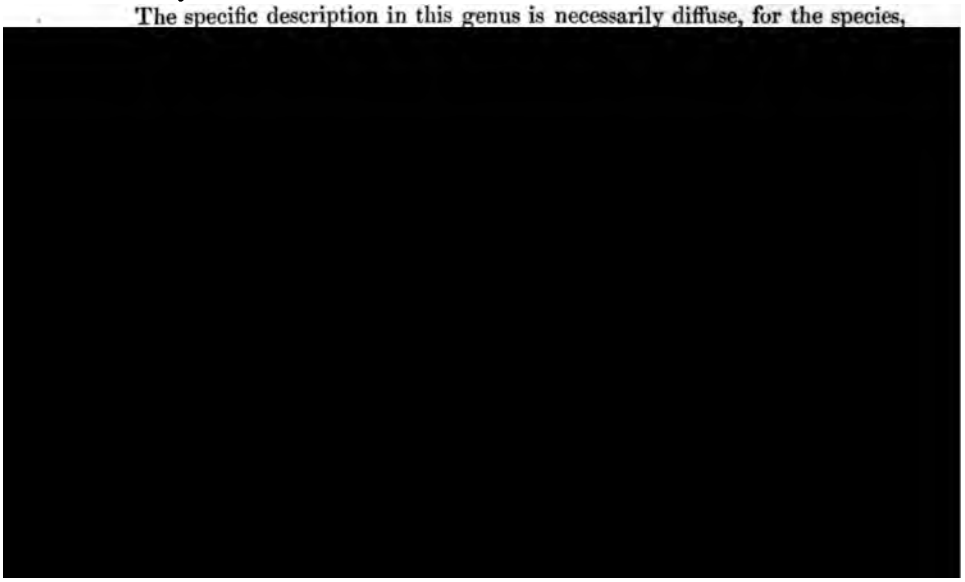
I. Rosenbergii, Eichwald.

Ref.—Pl. V., fig. 6, 7, 8.

Synonyms.—*Cryptonymus Rosenb.*, Eichw., per Ingriam, et de Trilob., Obs. 48, Tab. 3, f. 3; referred to *Illænus crassicauda*, Burm. (Transl. by Ray Soc. p. 103).

Specific character.—Surface with wavy lines and puncta; caudal larger than the swelled cephalic shield, and nearly twice as long as the thorax of ten segments; axal furrows of head about half its length; the eye nearer them than the edge, its own length from the neck margin; segments broad, flat, the axis nearly twice the breadth of the transversely-ribbed pleuræ, which are square at their ends; the fulcrum at the first fourth, the pleuræ scarcely bent at it.

The specific description in this genus is necessarily diffuse, for the species,



axal lobe above, but at the first fourth below; the pleuræ in front turned a little back; the middle ones straight, the posterior slightly forward; axis of the large caudal shield scarcely marked, and the upper fold not strong. Our species a good deal resembles *Ill. giganteus*, Guettard, from the clay-slate of Angers; a species very desirable for English travellers to procure, as it is not well known.

Locality.—Llandilo Flags, Llandeilo.

I. Bowmanni, Salter.

Ref.—Pl. VIII., fig. 1, 2, 3.

Synonyms.—*Ill. centrotus*, Portl. Ordn. Geol. Rep., 300, Pl. 10, f. 3 to 6, and probably f. 9 (not of Dalman). *I. Bowmanni*, Salter, in Quart. Geol. Journ., vol. i. p. 20 a, &c.

Specific character.—Smooth; cephalic and caudal divisions nearly equal, each longer than the short thorax of nine segments; axal lobe of head with converging furrows, less than half-way up; eye very near the outer edge, about its own length from the neck margin, and subtended by a strong neck furrow; axal lobe of body not convex, a little broader than the narrow flat pleuræ, which are slightly bent back at the fulcrum, at half, and convex from thence.

Head rather larger than the caudal shield, and convex; the eyes small, semilunar, very distant; this latter character, with the nine narrow thorax segments, will easily distinguish it from the preceding species; also from *I. crassicauda*, and from *I. Davisii*, a species described by me for Professor Sedgwick's work.

Locality.—Occurs abundantly in the calcareous portion of the lower Silurian rocks near Haverfordwest and Llandilo, extends into North Wales, and also the north of Ireland. Our figs. 2 and 3 are Portlock's specimens from Tyrone; fig. 1, Llandowror.

Ogygiæ, *Emmr.*

Lichas, Dalman.

We are indebted to Beyrich for the first real description of this genus, for Dalman, in naming it, gave no characters, except the specific one from the shape of the tail; and he placed the head in *Ampyx* with doubt. Eichwald afterwards named the head *Metopias*; Eaton and Portlock the entire animal *Nuttainia*. Strictly speaking, Castelnau's name *Platynotus*, accompanying Green's unequalled specimen, *P. Boltoni*, ought to have the preference; but Dalman's names are classical when we can use them. (*See Beyrich on Bohemian Trilobites*, Berlin, 1845, *for description.*)

Hawle and Corda divide this genus into *Dicranopeltis*, *Lichas*, *Acanthopyge*, *Dicranogmus*, and *Corydocephalus*.

L. LAXATUS, M'Coy.

REF.—Pl. VIII., fig. 4, 5, 6.

SYNONYMS.—*L. laxata*, M'Coy. Synopsis Sil. Foss. Irel. t. 4, f. 9. *L. pumila*, ib. f. 8; tail of *Calym? forcipata*, ib. f. 14 (not the head).

[Compare also *L. dissidens*, Beyrich, l. c., f. 18.]

SPECIFIC CHARACTER.—Head convex, with a narrow border in front (not produced), surface finely tubercular, with intermediate granules; glabella convex in front, quite overhanging the roundish-oblong deeply circumscribed side lobes, and very narrow between them; accessory lobe distant from the side lobe, and under the large eye; tail triangular bifurcate and produced at the apex; two narrow spines on each side; all three lateral lobes bisected, the inferior largest; its axis convex lanceolate long-acuminate, with four distinct and two obscure furrows.

In this genus, also, till we have more complete individuals, the specific character must be minute. *Lichas dissidens* is largely tubercular on the tail, which, moreover, wants the bisecting furrow in the lowest lateral lobe, and the apex is more produced before bifurcation: they are, however, close allies. Our species has the head of *Lichas*, but the tail is rather that of *Corydocephalus* (Hawle and Corda.)

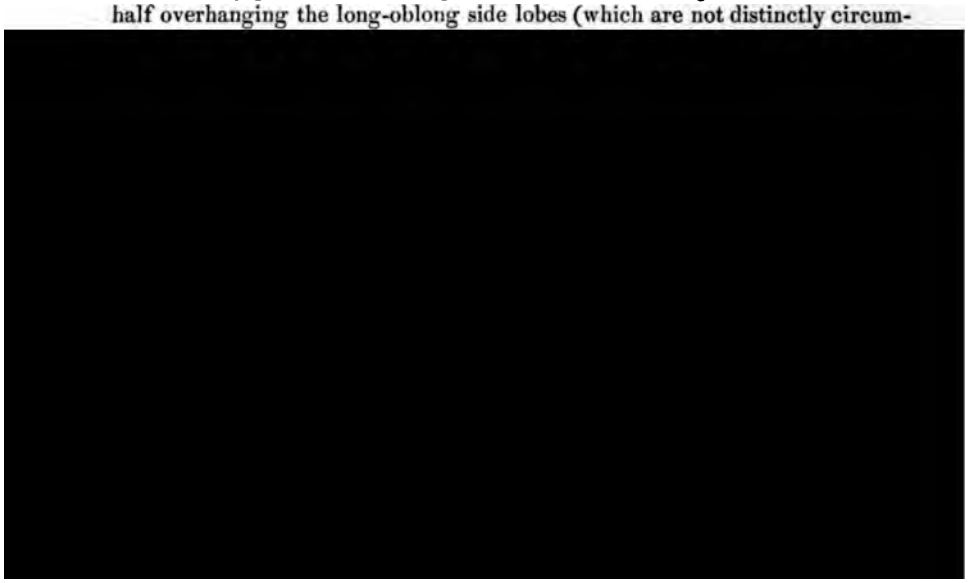
Locality.—An abundant species in the Llandeilo flags, and distributed apparently all through Britain. Our fig. 4 is from Shole's Hook; 5, from Bala; 6, Horderley (In Rev. T. T. Lewis's collection.)

L. VERRUCOSUS, Eichw. sp.

REF.—Pl. VIII., fig. 7.

SYNONYMS.—*Metopias verrucosus*, Eichwald, Urwelt Russl. 2nd pt. 63, t. 3, f. 23.

SPECIFIC CHARACTER.—Head convex with a narrow front border, its surface coarsely granular with large and small tubercles; glabella not convex, half overhanging the long-oblong side lobes (which are not distinctly circum-



CALYMENÆ, *Emmerich.*

The genuine *Calymenæ*, and that group represented by *Cybele* (Encrinurus) seem to be naturally connected, though forming two distinct sub-sections. But it is remarkable that Emmerich should have characterized the eyes as "not seated on conical protuberances," since *Cybele* has eyes more elevated than occur in any other trilobite.

I think the *Calymenæ* form a complete group, and the relations of the genera may be expressed thus:—

Contractile, compact, tail entire of moderate size.

CALYMENE, proper.

Contractile, convex, tail laciniate.	Scarcely contractile, flat; tail entire small.
AMPHION, Pander.	CONOCEPHALUS, Zenker.
CYBELE, Lovën.	CONOCORYPHE, PTYCHOPARIA. H. & C.
SPHÆREXOCHUS, Beyrich.	PARADOXIDES, Brongn.*
CHEIRURUS, *ib.*	OLENUS, Dalm.

I cannot admit *Homalonotus* here; it certainly has its principal relations with *Isotelus* (*Asaphus*).

CALYMENE BREVICAPITATA.

REF.—Pl. XI.

SYNONYMS.—*C. brevicapitata*, Portl. Geol. Rep. Pl. 3, f. 3. *C. parvula.* Barrande Syst. Sil. et Trilob. Bohem. 1846, p. 27. Hawle et Corda Böhm. Tril. t. 5, f. 50.

SPECIFIC CHARACTER.—Nearly semicylindrical, elongate; head subtriangular, front produced reflected; eyes a little in advance of the second lobe, on narrow gibbous cheeks; glabella short, conical, with two distinct lobes, a third small, and hardly distinct from the small terminal one; body rapidly narrowing backwards, regularly convex, axis as broad as the pleuræ, which are curved down at a right angle from the fulcrum, at one-fourth anteriorly, close to the axis behind; caudal shield small, subtriangular, the sides deflexed and incurved, axis three-fourths the length of caudal shield, of six or seven ribs; lateral ribs six, strongly duplicate all the way.

A beautiful specimen lately found at Bala (figs. 1, 2, 3), shows the connection of the English specimens of the head are identical with that part in those from Bala. It is interesting to find this small species of the genus so widely spread. It has not yet been found in America.

Locality.—Abundant in the Llandilo flags of North and South Wales. Figs. 4, 5, are large specimens from Llandilo.

* Nearly related to *Paradoxides*, and apparently connecting it with *Conocephalus*, &c., are several genera instituted by Hawle and Corda,—*Micropyge*, *Herse*, *Endogramma*, *Selenocema*, and perhaps *Staurogmus*.

Calymene tuberculosa, Salter.

Rep.—Pl. XII.

Synonyms.—*C. Blumenbachii var. α tuberculosa.* Dalm. Palæad. t. 1, f. 2; Hising. Leth. Suec. t. 1, f. 3; *C. Blumenbachii*, in part, Murch. S. Syst., t. 7, f. 5.

Specific character.—Depressed; anterior margin of the head broad, produced and reflexed; eyes a little in advance of the second appendiculate lobe, and at some distance, on gibbous cheeks; glabella much narrower in front, with two distinct lobes, and generally a third, minute; forehead small, not convex. Axis of the body rings convex, two-thirds the breadth of the pleuræ, a distinct tubercle on each side; pleuræ flat half-way, then curved to a right angle, sulcate, the posterior half more prominent; fulcrum at one-half above, one-quarter below; caudal axis flattish, rather narrow, with seven strong rings, sub-tuberculate at their ends; limb arched downwards with five flat ribs and furrows, faintly interlined for the whole length. Surface minutely granular all over the body.

Dalman seems to have noticed the difference of punctation in this animal from that of *C. Blumenbachii, vera*, of his work, and Hisinger merely copied his remarks. But succeeding authors have been disposed to overlook minute differences in favour of the general similarity which the species of *Calymene* exhibit. Green was the first who ventured to separate the American species into three or four, and his distinctions, I believe, are good upon the whole. The form of the projecting front, the general convexity or flattening of the pleuræ, the punctation, shape of tail, &c., are all available in this genus; and the present, though hitherto confounded by British observers, is unquestionably a distinct species from the more common *C. Blumenbachii*; in this last, the form is much more convex, the front margin narrow, eyes more backward, cheeks not swollen, glabella longer and its terminal lobe inflated; the axis of the body broader in proportion to the pleuræ, which are gently curved, not angularly bent, and have the two halves (separated by the furrow) of equal prominence; the tail, with its lower edge not inflected, marked with strong ribs, not narrow deep lines; and lastly, the granulation is of unequal size;

the more complete description requires us to accept *Cybele*. The eyes in this genus are very remarkable, elevated on a tall footstalk, the lentiferous surface half surrounding the apex on the outer side; the side ribs of the tail are very few compared with those of the axis, and their extremities are free and generally spinous. Hall in 'Paleontology of New York' (ined.) has included this genus in *Ceraurus*.

Cybele sexcostata, Salter.

Ref.—Pl. VIII., fig. 9, 10.

Specific Character.—[Glabella convex, posterior half parallel-sided, with three short lobes on each side, upper part suddenly expanded semicircular; eye tubercle a narrow cylinder. Head covered with large mamilliform tubercles with a central pit, tubercles crowded on the frontal margin; lateral angles—?] Caudal shield subtriangular, flattish above, the sides deflected; axis nearly parallel-sided, with above 20 ribs, but smooth in the middle after the first third; lateral ribs six, strong, arched back, smooth, prominent at their tips.

The description of the head is purposely separated from that of the characteristic tail, as they are only found abundant in company, not united: and there is also another form of head rarely occurring, which is more clavate, and may possibly be the appropriate one.

The head we figure is remarkable for the parallel hind portion and the sudden expansion forwards of the glabella, the neck segment prominent, and all the furrows of the head deep and strong; toward the posterior angles the crowded tubercles disappear, and leave the surface of the thick margin smooth. There is an inflexion downwards of the front edge, but it is not produced outwards, as in some species. The caudal axis, which, as in the genus, ends before the apex of the tail, has rather stronger and coarser ribs than usual, and no central row of tubercles, such as exists in *C. punctata*, *rugosa*, *variolaris*, &c., and the side ribs are destitute of tubercles or spines.

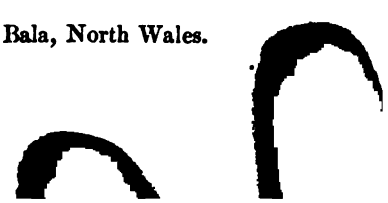
Localities.—Distributed through North and South Wales in the lower Silurian rocks. Figures from Sholes Hook, Haverfordwest.

Cybele verrucosa. Dalm., sp.

Synonyms.—*Calym. verruc.* Dalm. Pal. 76; ib. Arsberättelse 1828, p. 134; [Brong. t. iv. f. 11, cited by Dalm.] His. Leth. Suec. 11; *Cybele verrucosa*, Lovēn Ofv. Vetenskaps Acad., 1845, t. 1, f. 5, and p. 111; *Atractopyge verrucosa*, Hawle and Corda, Böhm. Tril., t. 5, f. 52.

This species, which would be difficult to recognize, if its determination depended on the first described specimen from Llandilo, is now confirmed by Lovēn's sufficiently accurate figure, which he took from native specimens. With us it occurs of large size, and abundantly, in certain Llandilo flag localities, viz.:—

Locality.—Sholes Hook, Haverfordwest; also Bala, North Wales.



C. VARIOLARIS, Brongn. (part.)

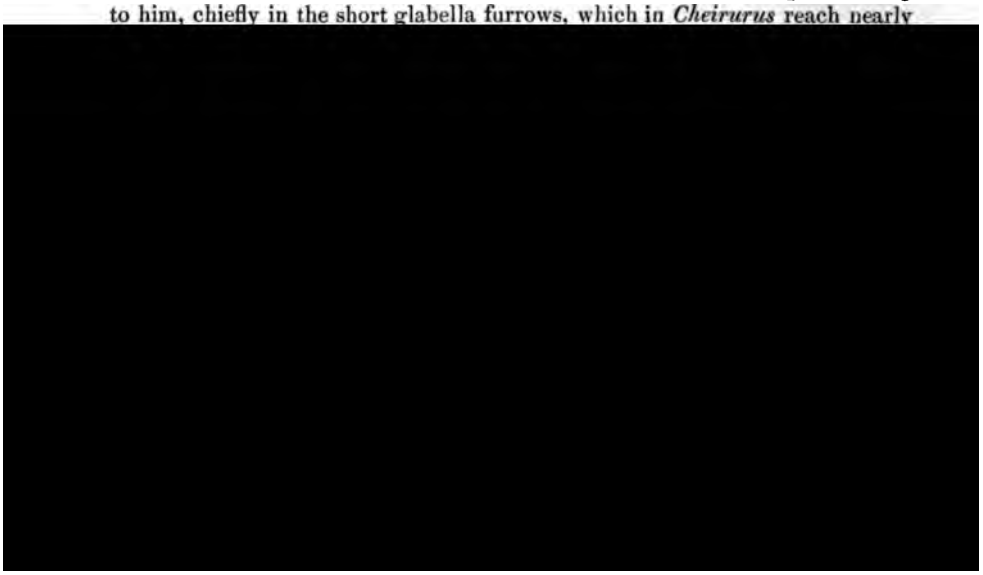
SYNONYMS.—*Calym. variolaris*, Brongn. t. 1, f. 3 B (not A). Murch. Sil. System, t. 14, f. 1. [exclude all other synonyms.]

Head triangular gibbous, about half as long as wide, covered with very coarse tubercles (each with a minute perforation or pit); glabella gibbous and overhanging, spherical, with a short neck, side furrows quite obscured by the size of the tubercles; neck segment (*spira*) smooth; eye moderately prominent, smooth above, nearer to the neck furrow than to the glabella; posterior angles of head rounded, with a prominent tubercle in place of a spine; front excavated below to receive the ovate sub-trilobed labrum, which does not reach forwards so far as the glabella; body segments 11, smooth, but with occasional elevations, especially on the central ridge of the axal lobe; tail triangular, convex and rounded at the end; nine coarse equal ribs on its convex axis, frequently interrupted in the middle by one or two isolated tubercles; side ribs seven, bent down, not spinous, but prominent at the ends; no terminal mucro to the tail.

The above description is given, not as a true specific character in the genus, but to show the many points in which this species differ from *C. punctata*,* Wahl., with which, as appears from his figure and description, Brongniart, followed by Milne Edwards, confounded it. His figure, 3 A, is undoubtedly (as was pointed out to me by Mr. Fletcher of Dudley), the *C. punctata*, a perfectly distinct species, and yet Brongniart's name has been universally applied to this more common Dudley fossil. There is no doubt he overlooked the difference, for the figure 3 B is a side view of our species, and therefore, though his description must be erased as applying to the *C. punctata*, fig. 3 A, it will be convenient to retain his well-known name for the present species. The *C. punctata* is found with this in beautiful preservation at Dudley.

SPHÆREXOCHUS, Beyrich.

Established by Beyrich very lately to include a few spherical trilobites, closely allied to *Cheirurus* in all essential characters, but differing, according to him, chiefly in the short glabella furrows, which in *Cheirurus* reach nearly



and two short anterior ones. Facial suture nearly vertical to the eye, thence at an obtuse angle to the exterior margin, a little in front of the lateral rounded angles; neck furrow strong, continued round the posterior angles; fixed cheeks as wide as the spira, scrobiculate.

We hardly know yet what are specific characters in this small genus, but the above description will agree very well with Barrande's, with the exception of a very important point: he describes a long process from each angle of the head, which would make it distinctly a *Cheirurus*. However, in the present, as in *Sph. clavifrons*, there is no appearance of such a process, and the edge is rounded off. We adopt, therefore, the name *juvenis*, from an appropriate MS. name of Prof. Phillips; it well expresses its smooth contour.

Locality.—Spread over North and South Wales in lower Silurian rocks of the age of the Llandilo flags. Our figures from Sholes Hook, Haverford-west.

Cheirurus, Beyrich.

This new genus is one of the most curious and best defined among the Trilobites; the spinose tail and singularly marked pleuræ at once distinguish it, nor are the characters of the glabella less important; the strong middle and upper lobes of the latter distinguish it from the only genus likely to be confounded with it, *Sphærexochus*—the posterior head angles are spinous. Hawle and Corda have separated *Selenosema* and *Eccoptochile* from it.

C. speciosus, Dalm., sp.

Ref.—Pl. VII., fig. 4, 5, 6, 7.

Synonyms.—*Calymene speciosa*, Dalm. Palead, 74. His. Leth. Suec. Supp. t. 39, f. 2. *Paradoxides bimucronatus*, Murch. Sil. Syst. t. 14, f. 8, 9. *Cheirurus bimucronatus*. Beyr. üb. Böhm. Tril. 19 (not *Arges planospinosus*, Portl.)

Specific character.—Sub-depressed, smooth; head semicircular, the front a little produced, posterior angles with short spines; glabella with nearly parallel sides, basal lobes triangular (in the older state with the inner angle truncate), separated in the middle, upper and middle furrows arched, shallow, not meeting across the glabella, but separated by less than one-third the width; cheeks at the base of the head as wide as that part of the glabella; eye of moderate size, convex, of numerous lenses, placed behind the middle of the head; pleuræ broader than the axis, a short strong oblique furrow on each reaching as far as the small prominent fulcrum at a little beyond the first fourth, beneath this internally is a strong vertical ridge; tail a semicircle (without the six broad recurved spines), the two hinder spines approximate, axis four-jointed, broad, pyramidal, its apex hardly projecting.

The above characters are necessary to distinguish our species from its ally *C. insignis*, Beyrich, which has a broad convex glabella with the

furrows distant in the middle, and the base ones forming triangles, also the spines of the tail more distant and narrower, the apex of the axis projecting strongly.

I can have no hesitation in referring the heads found by the Survey, and here engraved, to Hisinger's beautiful figure; but, by a curious train of evidence it turns out that *Paradox. bimucronatus*, Murch., is the same animal; figs. 8 and 9 of Murchison (fig. 9, however, being turned the wrong side up) evidently belong to one another; fragments of a body identical with fig. 9 have been found with the heads we figure, and in the neighbourhood the tail of Murchison's species is also found separate; the allocation, therefore, of these portions to the same animal becomes justifiable, especially as both head and tail present the closest affinity, yet not identity, with Beyrich's figure.* Some doubts are thrown by Beyrich on the identity of Hisinger's species with that of Dalman, but till these are settled we are not justified in applying a new name; I may also state that among Bohemian specimens *C. speciosus* occurs labelled by collectors as *C. insignis;* the shape of the glabella at once distinguishes them.

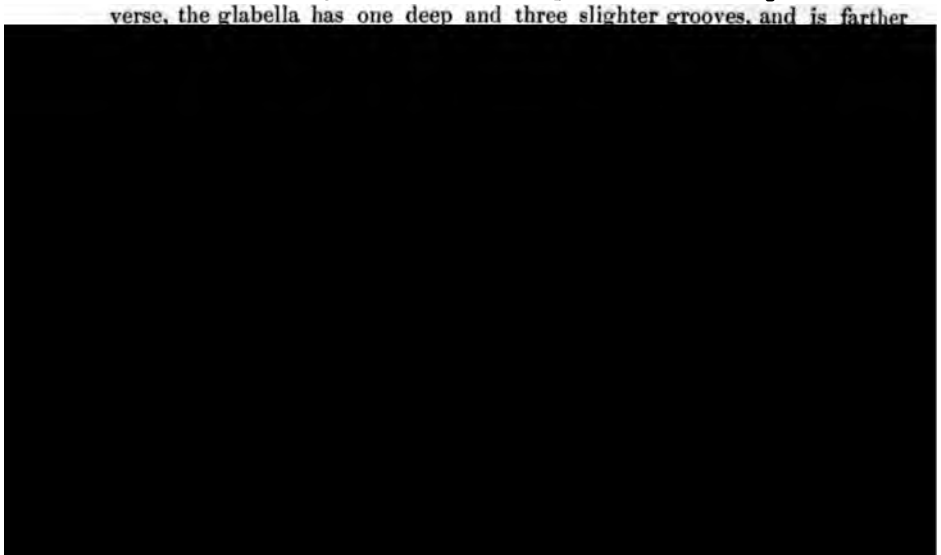
Locality of our figures. Sholes Hook; fig. 7, Nelson's Tower Wood, Llandilo.

Olenus bisulcatus, Phillips.

Ref.—Fig. 1, 2, p. 55, supra.

Specific character.—Cephalic shield with the front and hind margins straight and parallel; glabella narrowed and elongated to the anterior margin, marked with two deep transverse continuous grooves across the hinder part, and on the anterior oval part one slight marginal groove; ocular ridges directed backward so as to include an angle of 135°; a nuchal spine on the retral edge of the spira.

In general form of the cephalic region (the only part certainly known) it resembles *Olenus gibbosus*, but in that species the ocular ridges are transverse, the glabella has one deep and three slighter grooves, and is farther



Olenus humilis, Phillips.

Ref.—Fig. 4, 5, 6, p. 55, supra.

Specific character.—Middle lobe widest; lateral areas of the cephalic region narrow, tumid on each side of the glabella, and projecting beyond it forward; glabella much narrowed toward the front, divided across by two grooves posteriorly; the neck-ring one-spined, extending in width beyond the others. Cheek plates unknown.

The extreme narrowness of the tumid lateral cephalic areas is accompanied by a corresponding inward position of the eyes. (There is no appearance of an ocular ridge, except on one specimen.) Breadth of the cephalic shield only one-twelfth of an inch.

When first collected this little fossil seemed to be some kind of *Agnostus*, and as such was mentioned in the Phil. Mag. and Annals for 1843; but in the course of drying the specimens have become more distinct. It has sometimes seemed to me that this might be a young form—a trilobitic larva, but this is too important a point to be discussed without more complete specimens. In only two examples are the thoracic plates visible. They (fig. 4) show the mesial lobe to be much wider than the others, and thus resemble *Olenus scarabæoides*,* and the *Remopleurides* of Portlock.

Locality.—In the Black Shale of White-leaved Oak.—J. P.

Olenus spinulosus?

Ref.—Fig. 3, p. 55, supra.

Synonyms.—*Paradoxides spinulosus*, Brongniart, pl. 4, fig. 2: *Olenus spinulosus*, Dalman, pl. 6, fig. 4; Burmeister, p. 71.

Specific character.—Cephalic shield semilunar, truncate behind, the external angles extended in spines; abdomen with 12 joints; post-abdomen with six;† the transverse articulations terminating in spines bent backwards. (From Brongniart.)

Protuberance of the head parabolic; external spinous angles of the cephalic shield shorter than half the length of the body; trunk with 16 rings. (From Burmeister.)

The peculiar form and markings of the cephalic shield furnish the means of identification for this species. The glabella rounded in front, with straight sides widening a little posteriorly, its surface marked, in addition to the neck-furrow, by three oblique and undulated grooves (which are deep on each side of the mesial line, but scarcely reach the sides of the glabella), are strong marks for identification. On comparing specimens from Andrarum and Malvern, their close analogy is apparent, but only the cephalic shield has been found at Malvern. The cheek pieces in *Olenus spinulosus* are, as Brongniart figures them, covered with undulated striæ; his figure, which is

* Hawle and Corda adopt *Peltura*, Milne Edwards, for this species, and figure it in their work, Prodrom. Monogr. Böhm. Trilob. t. 6, f. 68.

† In Brongniart's description this is by mistake printed (sexdecim.)—J. P.

much better than Dalman's, would be improved by a certain straightening of the sides of the glabella.

Locality.—In the Black Shale of White-leaved Oak.—J. P.

The two following groups appear to be subdivisions of one section of equal importance with the *Phacops*, *Asaphi*, and *Calymenæ*. The whole group is remarkable for the great development of the margin of the cephalic shield, which is variously produced into a plicate, semiperforate, perforate, or spinous border; restricted in *Ampyx* to an anterior and two long posterior spines. *Acidaspis* has also the pleuræ of the body and tail spinous. The variations in the head margin may be regarded as modifications of a membranous expansion gradually contracting into perforations and ultimately spines (Quarterly Geol. Journ. for July, 1847). Hawle and Corda have figured an example of the plicate border in *Harpides*, t. 7, fig. 84.

Section ODONTOPLEURÆ, Emmr.

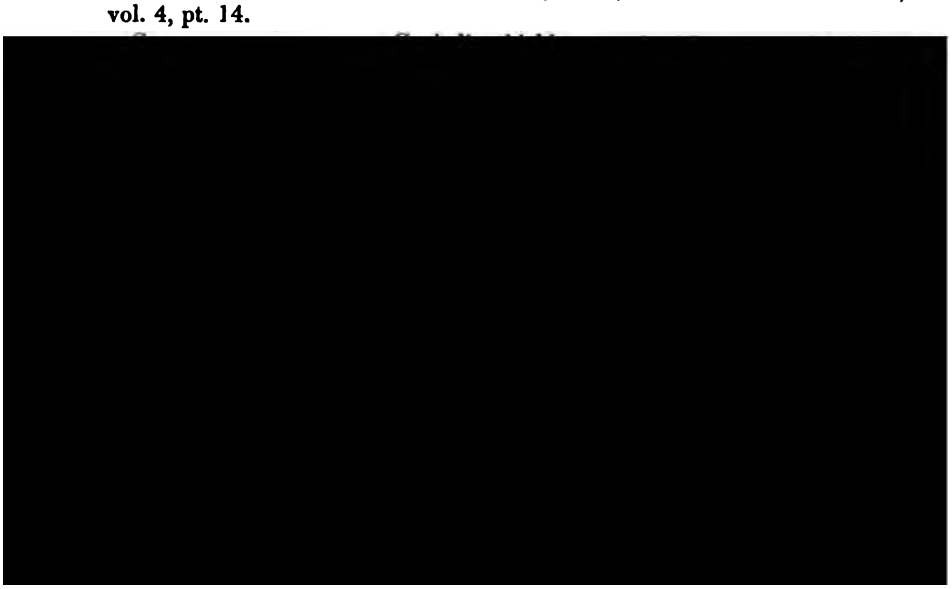
ACIDASPIS, Murchison; ODONTOPLEURA, Emmr.

Fully described by Dr. Emmerich from entire specimens. *Acidaspis*, however, is prior; the cast of *Ceraurus*, published by Green, and supposed by Lovën to be of this genus, is very indistinct; Beyrich refers it to his new genus, *Cheirurus;* and Hall (Palæont. N. York, ined.) confirms this view by minute description, and associating *Ch. speciosus* with it. Green's genus, so ill founded, must go out, by all Natural History rules.

A. BRIGHTII, Murch.

REF.—Pl. IX., fig. 6—9.

SYNONYMS.—*A. Brightii*, Murch, Sil. Syst. t. 14, f. 15; *Paradoxides quadrimucronatus*, ib. f. 10; (not *Odontopl. elliptica*, Burm.) *Odont. Brightii*, Emmr. Neues Jahrb. 1845. pt. 1. (Transl. Scientif. Memoirs, vol. 4, pt. 14.



Locality.—Fig. 6, Wenlock Limestone, Dudley (Mr. Gray's collection); 7, tail from Dudley (Geol. Soc. collection); 8, Vinnal Hill, cast of interior surface; 9, cast of tail, Vinnal Hill.

A. BISPINOSUS, M'Coy.

REF.—Pl. IX., fig. 4, 5.

SYNONYMS.—*A. bispinosus.* M'Coy, Synops. Sil. Foss. Ireland, pl. 4, f. 7 (not of Emmr. l. c.)

Our specimen is only an internal cast, yet it shows the character of the body rings, and the number of spines in the tail, and so adds considerably to our knowledge of this curious species. On an examination of the obscure original specimen at Dublin, the detection of the two cephalic spines was very difficult, and great credit is due to Mr. M' Coy, for making known this hitherto undescribed character.

The discovery of large individuals at Dudley, by Mr. John Gray (fig. 4 is one), which probably are the same species, but differ in the convexity of the glabella and distinctness of its side lobes, renders it advisable to examine all his beautiful series before attempting a specific character.

Locality.—It is the Dudley form, fig. 4, to which our specimen from Abberley belongs.

TRINUCLEUS. Llhwyd, Murchison.

T. ORNATUS, Sternberg, sp.

REF.—Pl. IX., fig. 1, 2.

SYNONYMS.—*T. ornatus*, &c. (Salter in Quart. Geol. Journ. Aug. 1847); *Nuttainia concentrica*, Eaton, Geol. text-book, pl. 1, f. 2; *Trinucleus concentricus*, Hall (Paleont. N. York, ined.); *T. ornatus*; *T. Bucklandii*; *T. Barrandei*; Hawle and Corda, Prodrom. Monog. Böhm, Tril. p. 39, 40, 41;* *T. Senftenbergii*, t. 3, f. 17? *T. cribrosus*, *elegantulus*, *minor*, *Pragensis*, ejusd.?

Having in the above quoted paper endeavoured to show that this curious species has been described under several names, we need not go over the same grounds; but it may be observed, that M. Barrande has, in his Supplement to his Observations on the Silurian Rocks of Bohemia, changed the opinion he before published; he transposes the reference to Steinberg's original figure from his *T. ornatus* to *T. Goldfussii*, and so reverses these names. As we have specimens of both forms, this admission only fortifies us in assuming that one of these is the true fossil of Sternberg, if, indeed, there were any doubt of it; and there is no difficulty in showing that they vary into each other. Hall

* Hawle and Corda, in the above quoted work, have retained Barrande's species; and added a new one, *T. Senftenbergii*, which, except for a slight difference in the shape of the tail (which is variable in our own specimens) cannot be separated from the old species: the spines are curved just as in *T. ornatus*, Barr. *T. cribrosus*, and *T. Pragensis*, are described from the heads; *T. minor* and *elegantulus*, in the absence of figures, do not present sufficient characters.

quotes too, *Cryptolithus tesselatus*, Green, as a synonym of *Nutt. concentrica*, Eaton; and Conrad says that the former is found in Ireland, where certainly it is *T. Caractaci*; all these names, however, are posterior to that of Sternberg. In the number of pores, and the amount of angularity in the front margin of the head the species is extremely variable, and if to this we add that a cast of the interior of the crust, or an impression of the upper or under surface of the fringe, all give different appearances, the reason of such discrepancies in identification may be accounted for. We describe one variety, not particularly mentioned before.

T. ORNATUS. var. δ FAVUS, Salter.

REF.—Pl. IX., fig. 3.

Head rectangular transverse; puncta in outer angles enlarged like honeycomb; glabella rather narrow.

The great enlargement of six or seven pores of the second and third rows on the external angles causes that part of the border to assume a sharp angular form, and even to overhang; the outer row of pores is not enlarged. Were it not for some specimens intermediate in character between this extreme form and the common one (too imperfect however to figure), we could hardly believe the two to be one species.

The variety δ occurs in groups in several parts of the Llandilo flags of South Wales. Our figure is from a Penblewin specimen.

AMPYX PARVULUS, Forbes.

REF.—Pl. X.

DESCRIPTION.—Cephalic shield triangular, the glabella forming its larger third. Glabella oval, very convex, extending much beyond the cheeks, gibbous along the median line, posteriorly sulcated at each side by two longitudinal converging furrows, between which and the cheeks are traces of eyes; cheeks small, gently curved, separated from the glabella by deep oblique sulci; spira indistinctly marked. Frontal spine twice or more

AGNOSTUS, Brongn.

Now proved, beyond a doubt, to be a simple form of trilobites, by the discovery, by Dr. Beyrich, of the entire animal in Bohemia; it appears to have only two joints in the thorax, and the tail differs from the head, by having a long tubercle or elevation on its central lobe; the two extremities are, however, much alike. Hawle and Corda have much extended our knowledge of this group.

A. TRINODUS, Salter.

REF.—Pl. VIII., fig. 11.

SYNONYMS.—*Trinodus agnostiformis*, M'Coy, Sil. Foss. Ireland, pl. 4, f. 3.

β. CONVEXUS, Salter.

REF.—Pl. VIII., fig. 12, 13.

Head and tail equally convex; glabella once and a half as long as wide; central lobe of tail forming part of the general convexity, and not raised much above the limb, which is wider at the end than at the sides.

Mr. M'Coy has only described the tail in his generic character, and in Irish specimens of the tail before me, I see some differences in the relatively less space behind the axal lobe, which, too, rises abruptly from a scarcely convex limb; M'Coy calls the latter very convex, and our Wexford specimens may have been pressed, but if so, the axal lobe would have suffered pressure also; the rim, too, is less distinctly separated. I have not seen the head of the Irish specimens, and it is hardly safe to separate the species on these grounds. I would adopt M'Coy's carefully described genus, but the differences from *Agnostus* (especially some of Beyrich's) seem only specific.

Distributed (β) through North and South Wales, our figures from Haverfordwest; the original variety, f. 11, in Wexford.

Family CYTHERINIDÆ. *Burm.*

Considered by this accomplished naturalist as more nearly related to the *Phyllopodous* genera *Estheria* or *Limnadia*, than to *Cythere*, and therefore an analogous group in the tribe *Palæadæ*, to that of the *Ostracoda* among the *Lophyropoda*.

BEYRICHIA, M'Coy.

M'Coy has been the first to announce this long-known animal as a bivalved crustacean, not a symmetrical-shelled trilobite. Beyrich also stated it, but without characterising the genus, in his paper on the Trilobites of Bohemia, already often referred to.

B. TUBERCULATA, Klöden.

REF.—Pl. VIII., fig. 14, 15.

SYNONYMS.—*Battus tuberculatus*, Klöden, Verst. der Mark Brand. t. 1, f. 16–18; *Agnostus tuberc.*, Murch. Sil. Syst. pl. 3, f. 17; *Cytherina* sp. Beyrich über einige Böhm. Tril. 47; *Agnostus pisiformis*, Salter in Quart. Geol. Journ., vol. 1, p. 20a. &c.; *Beyrichia Klödeni*, M'Coy, l. c. 58.

SPECIFIC CHARACTER.—Sparingly granulate, reniform, with a small oval subcentral lobe reaching half across: ventral rim narrow; caudal end larger and more prominent than the other.

Locality.—Distributed over the upper Silurian Rocks of Europe; our specimen, fig. 14, from Wenlock Limestone, Woolhope, fig. 15; Wenl. Shale, Tynewydd, Llandovery.

B. COMPLICATA, Salter.

REF.—Pl. VIII., fig. 16.

SPECIFIC CHARACTER.—Smooth, compressed, oblong, the end rounded; a thick rim round the ventral margin; three transverse tubercles united on the ventral edge, cephalic one deeply furcate, central one reaching quite across.

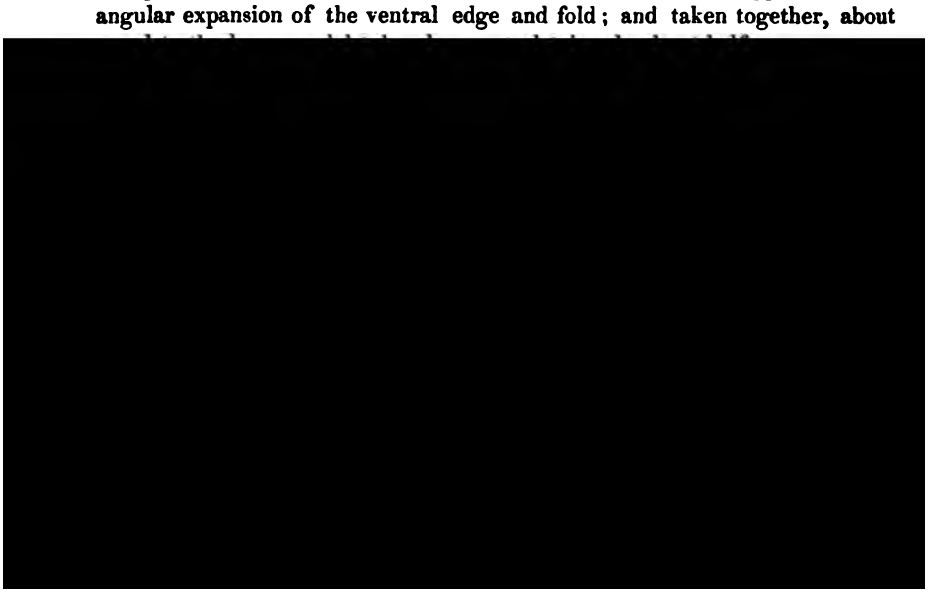
Our specimens do not show the ventral rim, which is very conspicuous in Professor Sedgwick's specimens from North Wales, it is a semi-cylindrical fold running nearly all round the ventral edge, and space for it is left in some of the internal casts in our specimens. We have indicated its course by dots.

Locality.—Llandilo flags of Lann Mill, &c.

B. GIBBA, Salter.

REF.—Pl. VIII., fig. 17, 18.

SPECIFIC CHARACTER.—Much compressed, subtriangular, the dorsal edge straight; cephalic and central tubercles short, transverse, opposite to an angular expansion of the ventral edge and fold; and taken together, about



forward to a point at the outer angles, and then concave backward across the front; whorls nearly as thick as broad.

This shell is very rare, indeed we do not know of more than one locality for it; the Lower Silurian grits of Mandinam, near Llandovery, in the quarry close to Mr. Rogers' cottage at Blaen-y-cwm. One fine specimen is in the wall of his house, another in the collection of the Geological Society.

It is left provisionally in the genus *Lituites*, in company with such discoid species as *L. Odini*, Eichwald*, and perhaps *L. cornu-arietis*, a section possessing interior siphuncles, and septa angularly bent to pass across the front. The discovery of De Verneuil, that in *L. Odini*, the siphon becomes mor central in age, is very curious, and shows a link between the true *Endosiphonites* (*Clymenia*, Munst.) in which it is constantly internal, and the *Lituites*, in which at least it is variable, and generally sub-central. It appears very probable that these discoid *Lituites* should form a section of the genus *Endosiphonites*, the lateral lobe being simply curved back and the ventral saddle being nearly a straight line across.—J. W. S.

Orthoceras Marloense, Phillips.

Ref.—Pl. XIII., fig. 1.

Specific character.—Incurvate, gently tapering (with a granulated surface?); suture circular; septa approximate, (about one-seventh of the diameter apart), oblique and somewhat waved: siphon nearly central.

Locality.—Wooltack Bay.

Remarks.—The incurvation of this species is sufficiently pronounced to separate it from any of the Silurian species which in the approximation of septa and circular suture, approach to it. It resembles *O. imbricatum*, but that has still closer and more oblique septa.—J. P.

Orthoceras textile, Phillips.

Ref.—Pl. XIII., fig. 5, 6.

Specific character.—Straight, very gently tapering, with a finely reticulated surface; section circular; septa distant (about half the diameter apart, but in this respect *unequal*); siphon marginal.

Locality.—Freshwater East, South side.

Remarks.—The marginal siphon as it appears to be, is a very strong distinctive mark, except when we compare it to *O. Steinhaueri*. The figure of that shell, given in the Geol. of Yorkshire, vol. ii. pl. xxi, f. 5, is very like the species from Freshwater East, but the shell is not reticulated, and the septa are still more distant.—J. P.

Orthoceras Brightii, Sow.

Synonyms.—*O. Mocktreense*, Sow. in Sil. Syst. t. 5, f. 11; *O. Brightii*, Sow. ib. t. 11, f. 21, 21*a*.

* See de Vern. Geol. Russ., 2nd vol., pl. 25, f. 8.

SPECIFIC CHARACTER.—Elongate, tapering slowly, a little more conical in the young shell, with coarse and very irregularly waved lines of growth; section circular, shell moderately thick; siphon large cylindrical, a sudden narrow constriction at each septum divides it into joints which are longer than broad; the diameter of the [excentric] siphon is much larger proportionally in the young shell.

A series of fine specimens in the collection of the Rev. T. T. Lewis of Aymestry, shows that the two above quoted species are exterior and interior parts of the same shell, and in all the localities hitherto noted, the shell is preserved in limestone, the siphon being filled with the dark calcareous mud, and all between it and the tube with white spar; no doubt the septa spring from the constricted parts of the siphon, but Sowerby has shown (supra f. 21*a*), that a membranous plicate bag occurs at each constriction within the outer cylindrical case, this bag reaching some distance above and below the constriction, and being itself strangulated by it. This is probably the basis of the various forms shown in the section of the siphon in many carboniferous species,* and especially in *O. giganteum*; in that species, however, the exterior of the principal sheath is longitudinally plaited.

Whether the internal bags communicate with the interior of the tube itself, or be inflated portions within the siphuncle tending to compress and return the fluids, we have not yet ascertained, but observations on *O. giganteum* render the latter the more probable supposition.—J. W. S.

ORTHOCERAS PERELEGANS, Salter.

REF.—Pl. XIII., fig. 2, 3, 4.

SYNONYMS.—*Lituites articulatus.* Sow. in Sil. Syst., pl. 11, f. 7. *L. Ibex*, f. 6 (not 5).

SPECIFIC CHARACTER.—Suddenly expanded in older state, and then nearly cylindric, crossed by rounded rings, which are near one another, not very prominent, and but slightly oblique, the striæ of growth very fine and close, in the direction of the rings; no longitudinal striæ; septa close, one

ovaries are to be developed, and the shell suddenly increase in diameter.* On examination of the originals, the species figured by Murchison has convinced me that the above views are correct; Mr. Sowerby agrees in them, and in the separation of the involute shell (pl. 11, f. 5) as a quite distinct keeled species, probably a *Lituites*. He would now restrict the name *L. articulatus* to this latter, and would readily agree to the union of the *O. Ibex* with the present species, on account of one specimen being striated both ways. Numerous specimens, however, of *O. Ibex*, from Westmoreland, show that the young shell was straight, and all have longitudinal striæ (a few have the transverse ones added), the septa in one specimen are between each *alternate* ring; our species never has longitudinal striæ.

Locality.—Upper Ludlow, of Usk Castle (also of Ludlow). *Lituites articulatus* is found in the same localities.

The nomenclature of the species above noticed, will then stand as follows:—

ORTHOCERAS IBEX, Sow. Sil. Syst., t. 5, fig. 30. *O. articulatum*, ib., fig. 31.

ORTHOCERAS PERELEGANS, Salt. supra. *Lituites articulatus*, Sow. Sil. Syst., t. 11, fig. 7. *L. Ibex*, ib., fig. 6.

LITUITES ARTICULATUS, Sow. Sil. Syst., t. 11, fig. 7.—J. W. S.

PTEROPODA.

THECA ANCEPS, Salter.

REF.—Pl. XIV., fig. 1.

Conical, mucronate, compressed, with two sharp edges, longitudinally finely striated; front and back equally convex [mouth rather constricted].

A small species, not in so good preservation as would enable us to pronounce on its structure with certainty, in the younger part it has a furrow within the sharp edges, on the dorsal? side; the striæ show on the internal cast. The lines of growth at the mouth appear to be gently waved downwards.

Locality.—The fine greenish shales of Eastnor Castle, in company with *Graptolites Ludensis*, thin *Orthoceratites*, &c.—J. W. S.

* This change from the young to the adult state takes place either at different periods in various specimens, or what is more likely, in dwarfed and vigorously grown individuals; the rings also (in both species) vary in relative distance: they are always proportionally more distant in the young.

HETEROPODA.

Bellerophon obtectus, Phillips.

Ref.—Pl. XIV., fig. 12.

Specific character. — Involute, umbilicate; the umbilicus nearly covered by the lateral expansions of the thickened edge of the aperture; mesial band very cariniform, the keel smooth; surface marked only by lines of growth.

Locality.—Marloes Bay.

Remarks.—This species resembles *B. Wenlockensis* of the Sil. Syst., but is less globular than even full-grown examples of that shell. It is more keeled than *B. oblongus.*—J. P.

GASTEROPODA.

Euomphalus alatus.

Synonyms.—*E. alatus*, His. Leth. Suec., pl. 11, f. 7. Murch. Sil. Syst., pl. 13, f. 28.

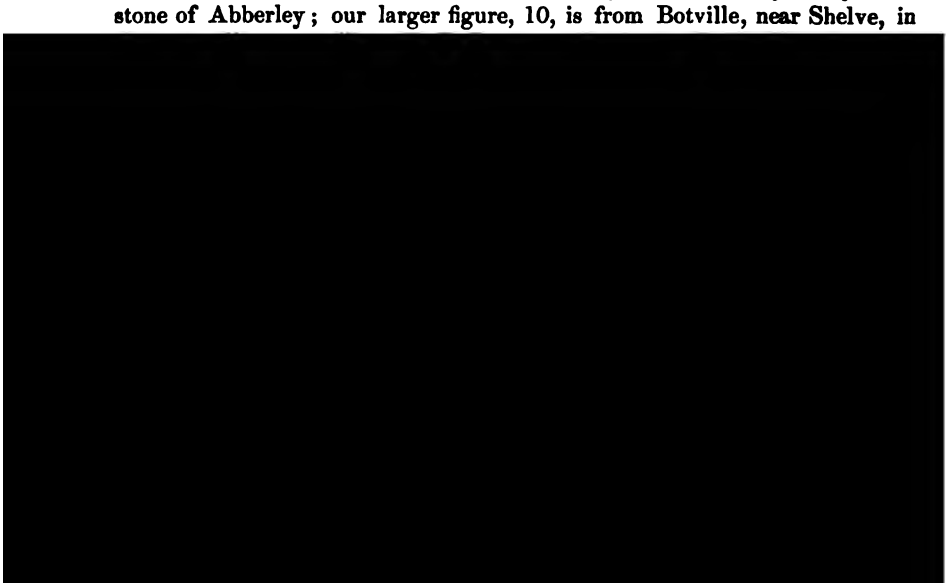
Var. subundulatus, Salter.

Ref.—Pl. XIV., fig. 8, 9, 10.

Wing in young state narrow; lines of growth fine; upper half of the whorls slightly waved along their upper surface; spire raised.

The young whorls of *E. alatus* are quadrate, with a prominent keel at the outer angle; as the whorls grow older, the lower half projects more; the closeness of the striæ is variable, and so apparently is the breadth of the wing; except on these specimens, we have not observed the undulations.

Locality.—Upper Ludlow, of Woolhope, figs. 8 and 9; Aymestry limestone of Abberley; our larger figure, 10, is from Botville, near Shelve, in



Euomphalus prænuntius, Phillips.

Ref.—Pl. XIV., fig. 11.

Specific character.—General figure rather depressed; the volutions carinated above, rounded, and spirally furrowed below; tranversely plicato-striate.

Locality.—Gunwick Mill (in Caradoc sandstone).

Remarks.—In general character it belongs to the group which includes *E. funatus* and *E. sculptus*. The keel on the upper part of the volution is surmounted by a plane horizontal space, and below it is a sloping concave space. Below this are three spiral ridges, succeeded by a conspicuous spiral furrow; then follow three smaller ridges, and another conspicuous furrow; one or two sharp ridges encircle the umbilicus. The transverse striæ are plait-like on the young whorls.—J. P.

Terebra? sinuosa.

Ref.—Pl. XIV., fig. 2.

Synonyms.—*Terebra sinuosa*, Sow. in Sil. Syst., t. 8, f. 15, (not of Phillips, Palæozoic Foss. Devon, f. 182).

This fine specimen, from the Rev. T. T. Lewis's collection, is here figured to show the size it attains, and the obscure band to which the lines of growth converge in the older state. It appears to be common in the limestone of Mocktree near Ludlow.—J. W. S.

Murchisonia? polyglypha, Phillips.

Ref.—Pl. XIV., fig. 3.

Specific character.—Turrited; whorls exserted, rounded, somewhat prominent above the suture, ornamented with numerous continuous nearly equidistant spiral striæ.

Locality.—Gunwick Mill (in Caradoc sandstone).

Remarks.—The analogy of this species to *Buccinum? parallele* of Phillips (Geol. of Yorkshire, pl. xv., f. 8), and *Loxonema reticulata*, Phillips, Pal. Fossils of Devon, fig. 187, is obvious. It seems to have been a larger shell, the last whorl being less disproportionate to the others than in those species. This is, however, a circumstance well known to be exceedingly variable in most of the Palæozoic gasteropods (e. g., *Cirrus*, *Pleurotomaria*, &c.)—J. P.

Pleurotomaria fissicarina, Phillips.

Ref.—Pl. XIV., fig. 5.

Specific character.—Trochiform, rather smooth; whorls four, spirally concave in the middle of the exposed upper parts, doubly keeled along the band, with faint spiral flutings below.

Locality.—The Wych, near Malvern (in Caradoc sandstone).

This species belongs to a group of *Pleurotomaria*, widely diffused in Devonian, carboniferous, and magnesiferous limestones, and is particularly

analogous to *P. interstrialis*, Phillips, (Geol. of Yorkshire, vol. ii., pl. xv., f. 10). It is apparently smoother, and has a deeper channel along its keeled band.—J. P.

Pleurotomaria quadristriata, Phillips.

Ref.—Pl. XIV., fig. 4.

Specific character.—Elongate, composed of three rounded volutions, which are marked below the middle with four spiral striæ *continuous above the suture*, and others below them. The lines of growth are conspicuously oblique and directed backwards.

Locality.—West of Rilbury Camp (Malvern District).

Remarks.—This has the general aspect, on a small scale, of *Buccinum parallele*, Phil. (Geol. of Yorkshire, vol. ii. pl. xvi. f. 8), but in that the upper part of the whorls is more planate, and the lower part has more and stronger furrows.—J. P.

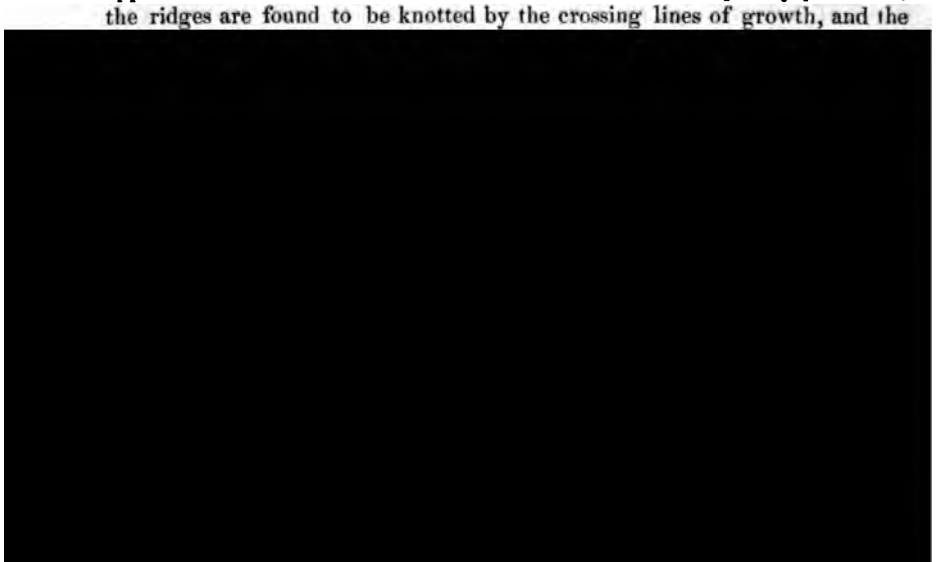
Pleurotomaria balteata, Phillips.

Ref.—Pl. XV., fig. 1, 2.

Specific character.—General figure ovato-rhomboidal; volutions three, exserted, rounded, covered with spiral ridges alternating with wider furrows, the broadest of which, with definite cariniform borders, forms a continuous supra-sutural band; lines of growth numerous, prominent, laminiform, especially between the ridges, bent retrally to and across the band; aperture two-thirds of the length of the shell.

Locality.—In Wenlock limestone, fig. 1, Hobbes, Longhope, near Woolhope; f. 2, ditto at Rock Farm in the May Hill District.

Remarks.—As the magnified figure shows, the whole surface bears a reticulated aspect, except on the band, where not only the space between the ridges is greater, but the squamous lines of growth are sometimes more approximate than elsewhere. Where the surface is completely preserved, the ridges are found to be knotted by the crossing lines of growth, and the



LAMELLIBRANCHIATA.

Pleurorhynchus æquicostatus, Phillips.

Ref.—Pl. XVI., fig. 1, 2.

Specific character.—Very obliquely deltoidal, ventricose; the cordiform depression bounded by a rounded ridge, much extended from the beaks, and bearing a short compressed (obliquely terminated?) umbo; surface covered with ridges and furrows radiating from the beak, every where nearly equal, at equal distances from the beak, and crossed by many fine equal striæ.

Locality.—Fig. 1, in Wenlock Limestone, Dormington Wood (Woolhope District); f. 2, an illustrative specimen from Dudley Limestone, in the cabinet of J. Gray, Esq., of that place.

Remarks.—It is seldom easy to assign exact characters to the species of this very natural Palæozoic group, except when many specimens can be employed. This advantage is not to be counted upon in the Silurian formations of the British Isles, where Pleurorhynchi are still very rare;—the present species fully rewarded a pleasant day's research in 1842. Though I have seen no specimens of Mr. Conrad's *P. vomer*, I venture to believe it distinct, on the grounds that the cordiform depression is less angularly defined, that the opposite ('anterior' of Conrad) side is less produced and more rounded, and that the umbo of the cordiform depression is much less prominent, and more compressed. Mr. Salter, who kindly suggested this comparison with Mr. Conrad's description, is, I believe, of the same opinion. In all the notices of British Pleurorhynchi, by Mr. M'Coy (see especially Carboniferous Fossils of Ireland), and myself, the side bearing the cordiform depression is regarded as anterior, but this is considered the posterior side by Mr. Conrad. This point must be kept in mind while comparing descriptions, and it may be settled when the affinities of the group are completely known: this knowledge is probably not yet attained; although Dr. Carpenter has shown in the shell of Pleurorhynchus a peculiar and large reticulation something like that in Hippurites—this is only one of the data necessary for determining its place in the series. The impression left on my own mind by some former investigations into the affinities of Pleurorhynchus was, that Hippopus offered the strongest general analogy to this Palæozoic group, but I have not lately considered the subject.—*J. P.*

Orthonota. Conrad, emend. Allorisma, King.

Family Mytilacea?

Generic character.—Long-transverse, closed at both ends, or but slightly gaping at the *posterior extremity*; beaks near the anterior, muscular impressions distinct, *not large, the posterior sub-marginal*; pallial impression entire, continued anteriorly beneath the beak, *hinge margin straight*, edentulous, thin; ligament *short, external*, half hid by an angular fold which continues along the dorsal edge; *beaks distant, convex*.

[Shell generally transversely furrowed; the left valve slightly more convex, often constricted at the anterior third, sometimes strongly.]

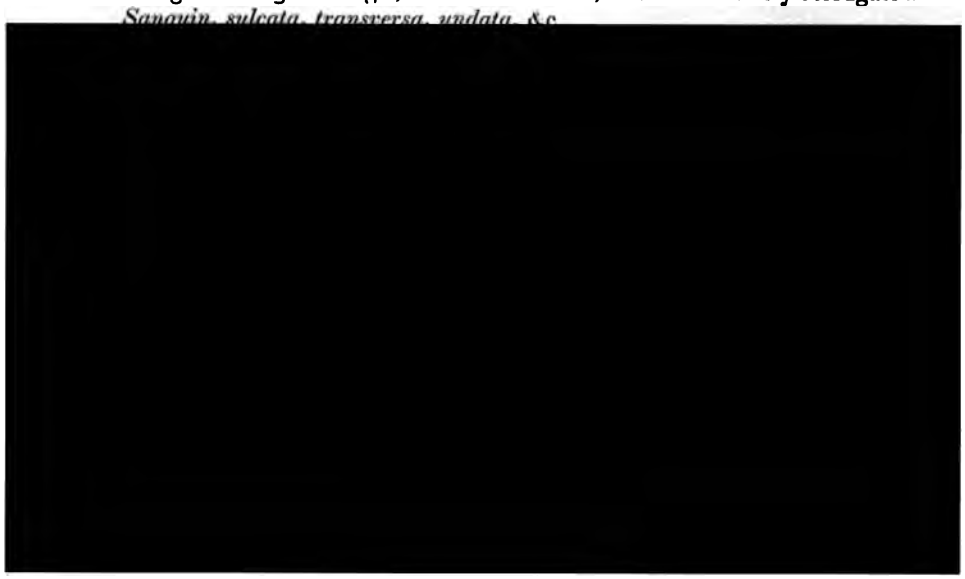
King's genus *Allorisma* was intended to include not only the Palæozoic species, but also *Myacites* of Schlotheim, and some other forms, with a sinuated pallial impression, &c. In his forthcoming monograph, however, (of which he has kindly sent the MS.,) he refers the *Sanguinolaria sulcata*, Phill., and the allied species, to *Edmondia*, De Koninck, on the supposition of their being provided with internal cartilage plates, while he restricts *Allorisma* to those species resembling *Hiatella sulcata*, *Myacites*, &c. But on examining the *Sanguinolariæ* of the mountain limestone, *S. transversa*, *contorta*, &c., I find no trace of such internal plates; on the contrary, both species have a short external ligament, and a peculiar fold along the hinge line; but there is an internal ridge running from the beak at some little distance below the hinge line posteriorly, in the species related to *S. transversa*, and I would suggest this to be the source of error. There would appear to be no advantage in separating the species included under the types of *S. contorta* and *tricostata*, from the Silurian group allied to *Mya rotundata*, and the transverse elongate species represented by *S. sulcata*, *transversa*, &c. *Orthonota*, Conrad, however, contains certainly shells belonging to this group, such as *O. pholadis*, *O. undulata*, and *O. curta*, Hall; *Cypric. sinuata*, Emmons, also belongs to this group. As Orthonota is the prior name, we must adopt it; it well expresses the straight dorsal edge.

We propose, therefore, to include in this extensive, but natural genus—

1st. The gibbous species, with short anterior sides, and strong lunette; smooth or transversely ribbed, such as *S. tricostata*, *contorta*, &c.

2nd. Convex species, smooth or ribbed on the anterior half, with anterior side as long or longer vertically than the posterior, and generally marked off by a constriction; lunette strong. The Silurian species of Cypricardia, *C. impressa*, *amygdalina*, *Mya rotundata*, *Modiola semisulcata*, &c.

3rd. Compressed or sub-compressed species, elongate posteriorly, with a strong sub-marginal ridge; lunette moderate; shell transversely corrugated. *Sanguin. sulcata, transversa, undata, &c.*



concave lunette; an oblique single (rarely double) furrow in the right valve, from the beak to the ventral margin, three approximate ones in the left.

The uniform covering of the surface by the irregular ribs, and the transverse parallel form, readily distinguish this from the next species; each, however, has a considerable range of variation in form.

The furrow terminates generally in the front half of the ventral margin.

Locality.—Fig. 1, Dudley limestone; fig. 2, Llanbadoc, Usk.

O. TRIANGULATA, Salter.

REF.—Plate XVIII.

SPECIFIC CHARACTER.—Sub-compressed, ovate-triangular, the beaks elevated and placed at the anterior third or fourth; oblique furrow single in the right valve, three approximate (sometimes obsolete) ones in the left; surface smooth, except the anterior side, which is strongly corrugated.

Easily recognised by its triangular form, and the position of the elevated umbo, which, though variably placed, is always considerably behind the strongly plaited anterior side; the furrow likewise terminates considerably behind the middle of the ventral edge.

Locality.—Figs. 3 to 7, varieties of form from the Trichrug, Llangadoc; figs. 1, 2, illustrative specimens from Westmoreland.

O. EXTRASULCATA, Salter.

REF.—Plate XVII., fig. 3.

SPECIFIC CHARACTER.—Sub-convex, transverse-oblong, equally and concentrically striated; beaks large, elevated, placed at the anterior third; three furrows in the left valve, the front one broad, shallow, vertical; the others oblique, sharp, inclosing a narrow ridge, and distant from the first one; right valve . . . . . ?

Of this we only know yet the left valve, and the peculiar bilobed character given to it by the broad deep anterior furrow, widely separated from the oblique ridge, suggested the name.

Locality.—South of the Trichrug, Llangadoc.

The above three species (or varieties as they may be esteemed by some) are very characteristic of the tilestone or uppermost Silurian beds of Wales and Westmoreland; and the first, *O. cingulata*, ranges through all the upper Silurian rocks, and is also found in Sweden. The characters of the above species appear constant, nevertheless there are specimens somewhat intermediate between *O. cingulata* and *O. triangulata*, at Dudley, in Messrs. Fletcher and Gray's collections. The group represented by these species appears naturally linked with our second section; some extreme oval forms in the Devonian rocks of France and North America have been elevated by De Verneuil to the rank of a genus, *Grammysia*. [Bull. de la Soc. Geol. de France, 2nd ser., vol. iv.]—J. W. S.

O. RIGIDA, Sow. sp.

REF.—Pl. XIX., figs. 1, 2.

SYNONYMS.—*Psammobia rigida*, Sow. in Sil, Syst., pl. 8, f. 3.

SPECIFIC CHARACTER.—"Sub-cylindrical," nearly four times as wide as long, with 12 or 13 sharp concentric folds, which become more numerous on the diagonal ridge; posterior side smooth, very long, with the sub-cardinal and two other faint furrows; beaks at the anterior sixth or seventh; "anterior side rather attenuated."

Mr. Sowerby had but a broken shell to describe from, and so did not know of the very long posterior side; his description is very accurate as far as it goes. Our shell is like *O. undulata*, Conrad—see Hall, Geol. Rep. N. York; but is wider still, and the corrugations do not cover the posterior slope.

Found W. of Wern, near Llandilo, in Upper Silurian Rocks.—J. W. S.

O. INORNATA, Phillips.

REF.—Pl. XIX., fig. 3.

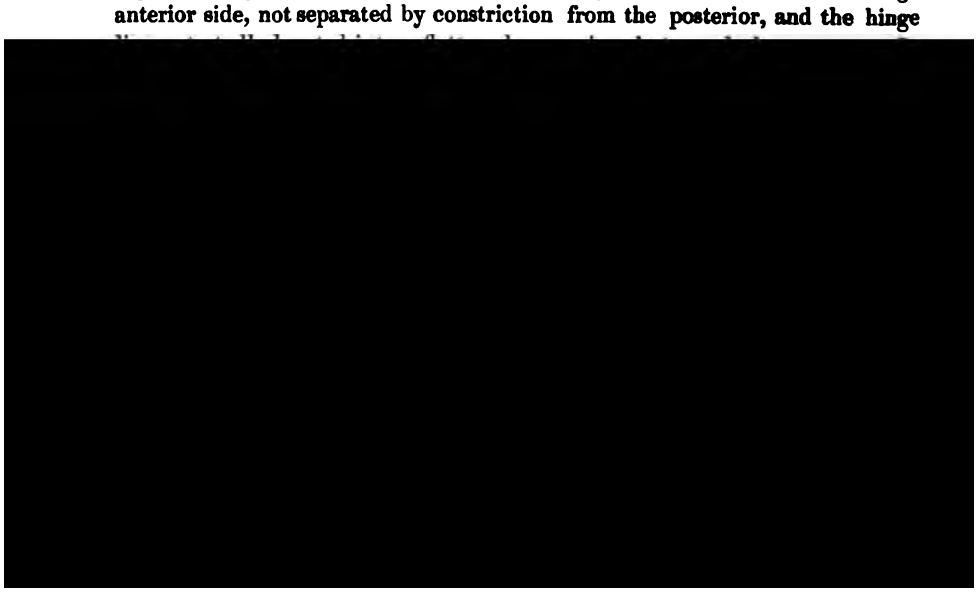
SPECIFIC CHARACTER.—Transverse, dorsal and ventral edges nearly parallel; the anterior side rounded in the quadrant of a circle; the posterior side oblique; surface convex, depressed in the middle, obliquely planate on the posterior region; the siphonal ridge very distinct, marked by many incremental striæ.

Locality.—Marloes Bay.

Remarks.—In *Orthonota rigida*, the incremental striæ rise to sharp plaits on the anterior part.—J. P.

MYTILUS, Linn.

As the genus *Edmondia* of De Koninck stands, it would appear to include a group of gibbous oval shells, concentrically ribbed, with a rather large anterior side, not separated by constriction from the posterior, and the hinge



M. GRADATUS, Salter.

REF.—Pl. XX., figs. 3, 4, 5.

SPECIFIC CHARACTER.—Transversely ovate, somewhat angular above, flattish but a little convex diagonally, not lobed at all, with three or four strong furrows or lines of growth, and a few intermediate striæ; beaks near the small rounded anterior side; posterior slope large triangular, obliquely truncate, but rounded off below; ligamental support not prominent, near the margin, reaching to about half the length of the shell; anterior muscular impression small, ovate, half-way down; posterior obscure.

A rather conspicuous shell from the marked periods of growth at wide intervals, and the even, not lobed general contour. It is like some of the American species, but we do not recognize any as identical. Fig. 5 is somewhat of a variety; *Modiola expansa*, Portlock, has a larger anterior side, is more gibbous and angular diagonally, the posterior wing not so flat, and its cardinal lamella nearer the edge; it is, however, very nearly allied.

Locality.—Common in the Upper Silurian (Ludlow) rocks of Shropshire and S. Wales.—J. W. S.

M. PEROVALIS, Salter.

REF.—Pl. XX., figs. 2, 2*a*.

SPECIFIC CHARACTER.—Truly elliptical, except a very slight flattening along the oblique hinge line, smooth with faint concentric lines; beak near the moderately large anterior side; ligamental support considerably within the margin, extending to the posterior third; a short oblique depressed line or internal ridge from the beak anteriorly.

A small remarkable species: the specimen is an external cast of the left valve, and the ligament, fulcrum, and anterior line show as ridges, consequently they should have been depressions outside, but as, in muddy strata, the internal and external casts get impressed on each other, from the two surfaces being soft at the time—these may be only interior markings; fig. 2 *a*, is an impression in wax from the hollow mould, and represents, therefore, the outside.

Locality.—Llanbadoc, Usk; in Ludlow rocks.—J. W. S.

M. QUADRATUS, Salter.

REF.—Pl. XX., fig. 1.

SPECIFIC CHARACTER.—Quadrate, the angles rounded, a little longer than wide, nearly smooth, with faint concentric lines; greatest length and convexity at right angles to the posterior hinge line, beneath which is a short slightly prominent ligament support.

Locality.—Dafaddfa-uchaf, Llangadoc; Upper Ludlow rock.—J. W. S.

M. PLATYPHYLLUS, Salter.

REF.—Pl. XX., figs. 13, 14.

SPECIFIC CHARACTER.—Transverse long-oblong, moderately convex diagonally. The dorsal line arched, the ventral sinuated in the middle; posterior side obliquely truncate; anterior corrugate, narrowed, projecting a little; beak at the anterior fifth, lower than the dorsal surface; ligament support a little curved, extending to the posterior fourth; muscular impressions rather distinct.

There are recent species from New Holland and South Africa, a good deal resembling this form, but they are generally more convex and distinctly lobed, while ours is but slightly depressed along the middle. The fossil species most nearly allied is *M. complanata* (*Pullastra*, Sow. Sil. Syst.) but that species is more regularly convex, and the sinus further back; the anterior muscular impression too, is very strong.

Var. β, fig. 14, not so wide, dorsal line and fulcrum more arched.

Both varieties are characteristic of tilestone of S. Wales, our specimens from the Trichrug, Llangadoc.—J. W. S.

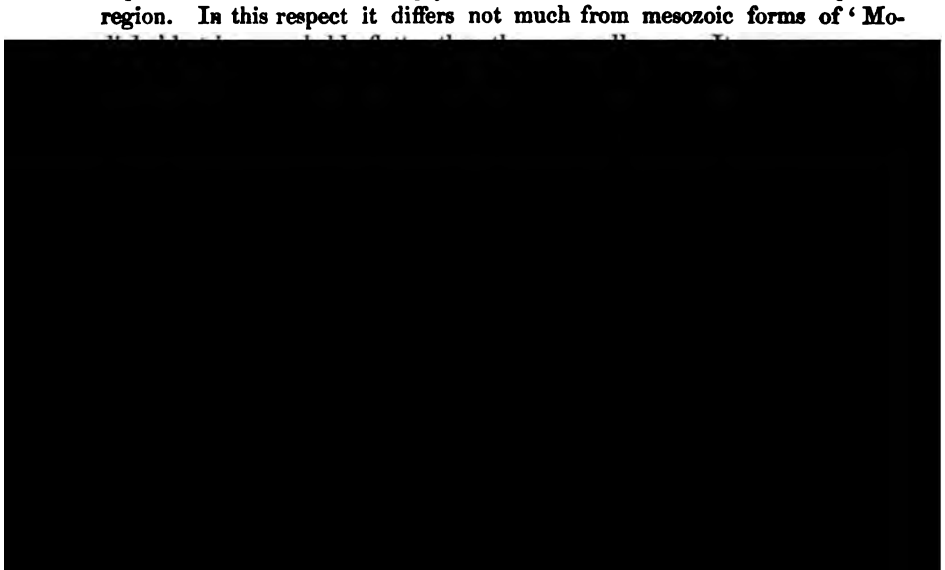
MYTILUS EXASPERATUS, Phillips.

REF.—Pl. XX., fig. 12.

SPECIFIC CHARACTER.—General figure depressed, obliquely extended, reniform, narrow toward the extremities; surface marked by very numerous close transverse sharply-defined ridges and furrows, which here and there lose their parallelism, and coalesce into stronger plaits over and beyond the siphonal region.

Locality.—On the Swansea road from Llandilo, Myddelton series.

Remarks.—The reniform figure of this shell arises from the broad convex expansion behind, and the deeply concave contraction in front of the siphonal region. In this respect it differs not much from mesozoic forms of 'Mo-



The young shell is proportionally broader than the old state, taking breadth and length in the obvious sense; but it is to be remembered, that in the genus *Mytilus* these terms have a different signification than in most bivalves. In the ordinary transverse form of bivalves, the length is greatest from the mouth or anterior end to the siphonal or posterior extremity; the height, from the beak to the ventral margin. As there is little or no anterior side, and the beak is terminal in the *Monomyaria* and this family, the length is generally greatest from the beak to the siphons, and the height must be reckoned from the ventral edge to the dorsal in the broadest part.

I am sorry that for so characteristic and curious a shell as this, the name cannot be quite settled. Conrad's *Inoc. oviformis* is rather broader than our shell, and his *I. Mytilimeris*, in other respects very like, has the cardinal lamella too near the edge, nor is it quite so regularly convex a shell. But his figures are barely more than outlines, and the description not sufficient; nor have we yet seen American specimens. *I. trigonus*, Portlock, is probably the same species.

Locality.—Caradoc Sandstone of May Hill, also of Tyrone; Wenlock limestone of Dudley, figs. 8, 9, (from Mr. Fletcher's Collection); Ludlow Rocks of Golden Grove, Llandilo; fig. 7.—J. W. S.

M. CHEMUNGENSIS, Conrad, sp.?

REF.—Pl. XX., figs. 10, 11.

SYNONYMS.—*Inoc. chemungensis*, Conrad. l. c., f, 9?

Our shell is smooth, or with faint lines of growth, ovate acuminate, with the long beak incurved, gibbous, the ventral side sunk, the beak curved over it; no anterior side; posterior wing small, the strong lamella nearly reaching the angle of it; two parallel teeth immediately beneath the beak; height less than two-thirds the length.

The young shell (fig. 17) is less gibbous of course than the old, and in our specimen has the lamella faint. We have only two specimens; of its identity with the Devonian species from America there is much doubt.

Locality.—Wenlock shale, Usk.—J. W. S.

M.? UNGUICULATUS, Salter.

REF.—Pl. XX., fig. 6, 6 *a*.

SPECIFIC CHARACTER.—Transversely narrow-ovate, lanceolate, acuminate at the anterior end, slightly lobed; the cardinal edge and anterior half of the ventral margin much thickened; ligament support thick, as wide as the shell [a thickened tooth? in the right valve under the beak, which is at the anterior fourth, and two small distant pits in front of it], ventral edge gaping in front for the byssus.

So like an imperfect form of *Gervillia*, that we were ready to enumerate it as such; however the hinge-line is bent, there is no distinct posterior

wing, and the hinge-pits are at least problematical; it is therefore unsafe to introduce a genus into the Silurian rocks on such obscure evidence.

Locality.—In the sandy Wenlock shale of Bryn Craig, Usk.—J. W. S.

ACTINODONTA* CUNEATA, Phillips.

REF.—Pl. XXI., figs. 1—4.

SPECIFIC CHARACTER.—Ovato-acuminate, anteriorly broad rounded, posteriorly narrowed, ventral edge rather sinuated. Surface convex (a little flattened or hollowed in the middle) with transverse incremental striæ. Hinge teeth radiating from the beak; on the anterior part and under the beak several short ones; on the posterior slope two elongated laminiform teeth. Muscular impressions strong anteriorly.

Locality.—Figs. 1, 2, Marloes Bay; 3, 4, Freshwater East, N.—J. P.

ARCA? PRIMITIVA, Phillips.

REF.—Pl. XXI., fig. 5.

SPECIFIC CHARACTER.—Transverse, narrowed and rounded anteriorly; widened and obliquely truncate behind. Surface evenly convex, except on the flattened posterior slope and the ligamental area, marked with fine longitudinal striæ, and distant incremental lines.

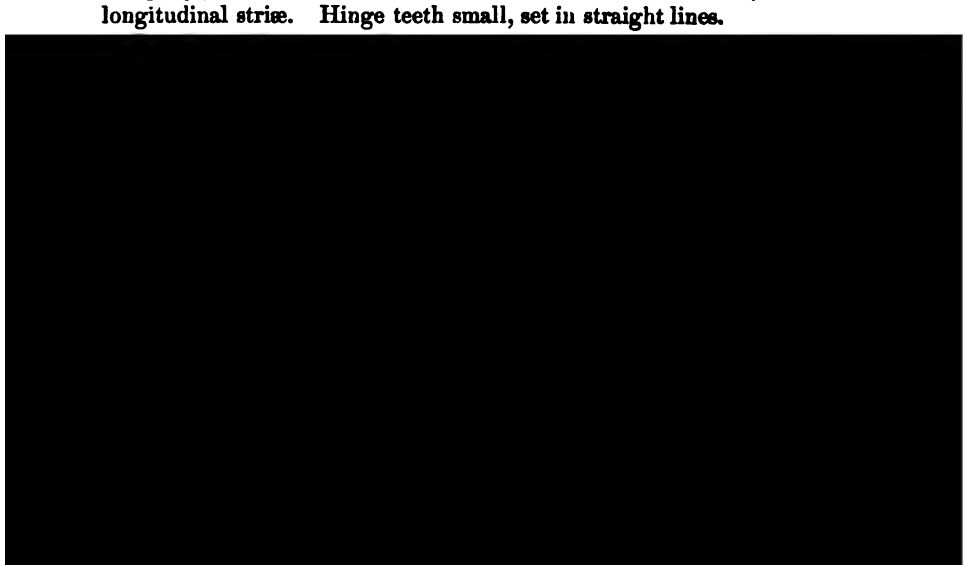
Locality.—Freshwater East, south side.

Remarks.—The figure looking down on either valve is semi-parabolic, the hinge line being the axis.—J. P.

NUCULA COARCTATA, Phillips.

REF.—Pl. XXII., figs. 1—4.

SPECIFIC CHARACTER.—Ovato-acuminate, rounded anteriorly, posteriorly contracted to a narrow ridge, and acuminated. Surface convex forward, obliquely planate behind, smooth, marked with fine transverse, and still finer longitudinal striæ. Hinge teeth small, set in straight lines.



NUCULA LINGUALIS, Phillips.

REF.—Pl. XXII., fig. 6.

SPECIFIC CHARACTER.—Ovato-acuminate, or almond-shaped, the ventral edge very evenly rounded. Surface evenly convex. Posterior hinge teeth set on a convex arched line.

Locality.—The Lower Caradoc beds at the Obelisk in Eastnor Park.

Remarks.—In the size and number of the hinge teeth it resembles *N. rhomboidea*. The shell was smooth on the surface, except where the incremental edges somewhat roughened it.—J. P.

NUCULA RHOMBOIDEA, Phillips.

REF.—Pl. XXII., fig. 7.

SPECIFIC CHARACTER.—Ovato-rhomboidal, rounded anteriorly, obliquely extended and sub-rhomboidal behind, with the ventral and dorsal edges straight and sub-parallel. Surface transversely striated, flattened along the middle. Hinge teeth small, above 20 posterior, about 8 anterior, placed on straight lines, obliquely and rather suddenly bent toward each end of the lines.

Locality.—In the Lower Caradoc beds at the Obelisk in Eastnor Park.—J.P.

MONOMYARIA.

AVICULA AMPLIATA. Phillips.

REF.—Pl. XXIII., fig. 1.

SPECIFIC CHARACTER.—General figure oblique, broadly ovate; hinge line straight with nearly rectangular terminations, from which the outline passes easily into the general oval sweep of the margin; surface depressed (its slight convexity being even and regular except on the small anterior ear, where it is a little folded in a line from the beak), transversely marked with striæ at regular distances, and a few broader undulations.

Locality.—The hill called Trichrug, Llangadoc, in purple laminated sandstone (Upper Ludlow).

Remarks.—Specimens are generally even more oblique than the figure we have given, and somewhat more fully expanded toward the part most distant from the beak. There is a depressed species (*Avic. Danbyi*, Salter), in the Upper Silurian beds of Westmoreland, not unlike this, but its surface is broadly radiated from the beak.—J. P.

AVICULA TRITON, Salter.

REF.—Pl. XXIII., fig. 5.

SPECIFIC CHARACTER.—Subrectangular, inflated, except towards the square angle of the posterior side; the gibbous beak falls considerably within the

anterior slope, which forms an obtuse angle with the cardinal edge, and is very steep and even concave; the shell is widest from the beak perpendicularly. Surface of the internal cast smooth, (exterior probably so), a few distant lines of growth on the posterior side; the cardinal edge slightly thickened and a shallow furrow beneath it not reaching the end. Height from the beak perpendicularly, two inches; length, transversely, two inches and three-eighths; depth of left valve, three-quarters of an inch.

About this fine species there remained for some time a doubt, till Mr. Baily, of the Geological Survey, had the good fortune to develope the posterior wing, and its character as an *Avicula* was then plain; but it presents an unusual gibbosity, width, and expansion in front of the beak. The posterior side is usually the most developed in this genus, but the beak of the present species falls considerably within the anterior margin, when a line is drawn perpendicularly from it downwards; the great gibbosity, too, is beneath the beak, not in a diagonal line from this to the siphonal end; so that the entire shell, divested of the somewhat depressed posterior slope, has more the appearance of a *Trigonia* than an *Avicula*. The anterior lobe is quite obsolete, and there is a depression, roughly resembling a lunette, on the steep anterior side.

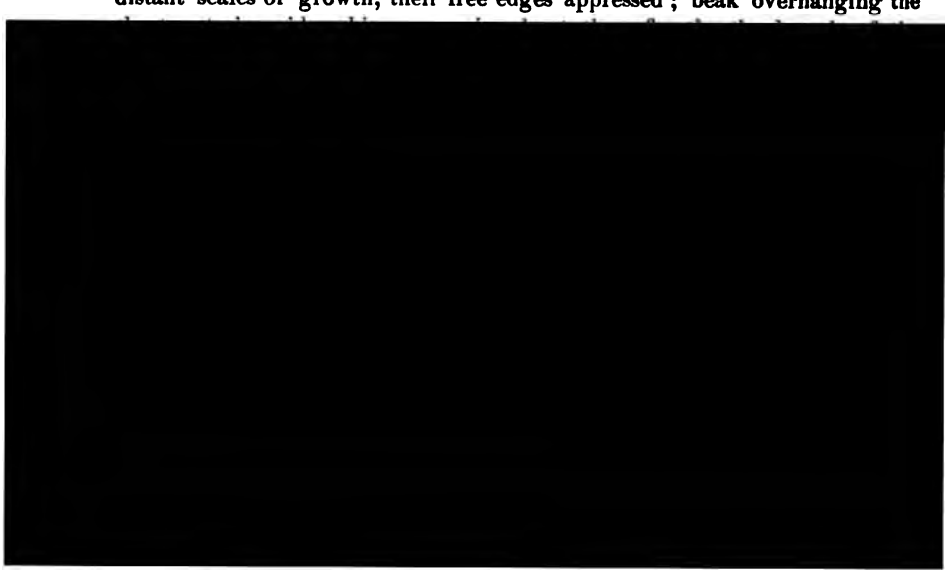
Locality.—Bird's Hill, in Llandilo flag limestones; a very rich bed, filled with large *Illæni* and other Trilobites.—J. W. S.

PTERINEA? PLANULATA, Conrad.

REF.—Pl. XXIII., figs. 2, 3, 4.

SYNONYMS.—*Pterinea planulata*, Conrad Journ. Acad. Nat. Sc. Philadelph. vol. viii., pt. 1. Pl. 13, f. 15.

SPECIFIC CHARACTER.—Inequivalved? moderately convex diagonally, transverse; the posterior side broadest and largest, divided by a constriction in the ventral edge from the small anterior side; in the left valve a sinus in the lines of growth along the posterior slope; surface with elevated equidistant scales of growth, their free edges appressed; beak overhanging the



The shell has very much the aspect of a *Modiola*, but if the valves are unequal, it is the right and not the left one that is the more ventricose. We must wait for more specimens therefore to settle the genus.

Conrad's Description.—"Subovate, with angular concentric sulci; valves flattened, swelling slightly over the umbonial slope, which is rounded with a *depressed line* on its posterior margin; hinge margin elevated, much shorter than the length of the shell, its summit not prominent; anterior margin very obliquely truncate; posterior extremity acutely rounded. *Locality.* Helderberg Mountains."

Locality.—Distributed pretty generally through the Lower Ludlow and Wenlock rocks, abounding at Dudley and the neighbourhood in the shales. —J. W. S.

BRACHIOPODA.

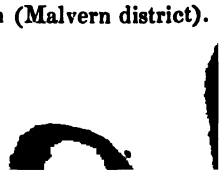
In describing the following few species of Brachiopoda the terms dorsal and ventral valves are always applied to those which have been determined by anatomists to cover those respective regions. There seems no reason for establishing a directly opposite nomenclature, though it has lately been much used. By the ventral valve, then, is meant the perforated valve in *Terebratula*, and the analogue of which is the receiving valve in other genera, having generally the most prominent beak; the dorsal being that to which the apophysary system, spiral arms, &c., are attached. To prevent unnecessary multiplication of terms, the central elevation of the dorsal valve is called the dorsal fold, the corresponding depression in the opposite valve, the ventral sinus. King has suggested the name "condyle and socket plates" for the two vertical laminæ which diverge from the beak of both valves, yet these terms are hardly admissible, seeing that there are decided teeth in both valves. It seems better to retain the old name "teeth" for both; and to speak of dorsal and ventral "hinge-plates," when such extend from the teeth of either valve;—a plate or ridge verygenerally rises along the middle of the dorsal valve—"central" seems preferable to "mesial" plate.—J. W. S.

LINGULA CRUMENA, Phillips.

REF.—Pl. XXIV.

SPECIFIC CHARACTER.—General figure triangular, acuminated toward the beaks, the front rounded (with a tendency to straightness in the middle), the sides a little concave at about half the length from the beak, and a little convex nearer to the beak; surface somewhat irregularly marked by strong lines of growth, and often striated by the projection of the radiating fibres of the shell structure.

Locality.—In Caradoc sandstone at Howler's Heath (Malvern district).



Remarks.—This rare shell is of the largest size attained by Lingulæ, and varies considerably in appearance. Young and delicate specimens make a near approach to *L. attenuata* which very often occurs in the Caradoc sandstone; but that is a neater and smoother shell, with hardly any trace of the fibrous rays. There is no example of the two valves conjoined, but both in this species and its contemporary, *L. attenuata*, there is at least cause for inquiry whether the shell is really equivalve. I have found specimens of *L. attenuata* which seemed to answer this question in the negative, and induced me to propose for consideration a new generic group (*Glossina*). No examples of *L. crumena* demonstrate clearly the inner surface of the shell.—J. P.

Lingula granulata, Phillips.

Ref.—Pl. XXV.

Specific character.—General figure pentahedral, the sides parallel for a great part of their length, rounded into the straight front and the straight slopes which unite in the beak at an angle of 120°. Convexity of each valve formed in planes corresponding to the straightened edges, and similarly rounded into one another; surface granuloso-reticulated, especially on the mesial region, by many transverse regular striæ, which are crossed by numerous lines corresponding to the regular fibrous texture of the shell; internal mesial impression narrow, elongate.

Locality.—In the limestone of Llandilo, &c.

Remarks.—The transverse striations are formed in sets, being extremely regular and at equal distances for many rows, and afterwards equally regular but at smaller distances apart. The surface appears granulated. The reticulation is less evident on the sides and on young individuals. In young specimens the outline is less characteristically marked, being in fact ovato-acuminate. (In other Lingulæ, as in this, the lateral expansions near the beak increase and become characteristic with age.) The shell is always very black, and its small reticulated fragments have been found in several places about Llandilo.—J. P.

ORBICULA FORBESII, Davidson.

REF.—Plate XXVI., fig. 2.

SYNONYMS.—*O. Forbesii*, Davidson, in London Geological Journal, 1848 (ined.).

The very interesting shell we figure forms part of a small but peculiar group of ancient *Orbiculæ*, in which the lower as well as the upper valve is convex; the perforation in the lower valve is narrow, and situate in a deep sulcus, reaching from the excentric umbo nearly to the margin. The upper valve we have not seen, but, as Mr. Davidson is about to describe and figure the species fully, it is unnecessary to add more particulars. F. 2 *b* is a magnified view of the foramen (closed, except at the lower end?).

Locality.—Wenlock limestone, Dormington-wood.—J. W. S.

LEPTÆNA LEPISMA, Dalman.

SYNONYMS.—*L. lepisma*, Dalm.; Sowerby, in Sil. Syst., t. 8, f. 7.

Var. MINOR, Salter.

REF.—Plate XXVI., fig. 3, 4.

Our shell is small, thin, silky, convex, smooth, subquadrangular, wider than long, the upper angles a little produced and flattened; hinge plates very obscure; dorsal valve regularly convex, its medial plate reaching nearly halfway, thin, sometimes bifid, a few tubercles inside towards the angles; ventral valve very concave, thin, prickly inside, except towards the angles, hinge teeth small, diverging at 120°, medial teeth bifid, central plate faint, thicker above.

The original specimen, referred by Mr. Sowerby to Dalman's species, appears to agree closely with our shells, except that the latter are smaller constantly, and have the lateral angles a little more produced, in the way of *L. lævigata*, Sow. We doubt the distinctness of this latter, but it has regular though faint ribs and concentric striæ.

Locality.—Fig. 3, Builth, abundant in the Upper Silurian; 3 *a*, interior cast of ventral valve magnified; fig. 4, from Aymestry; 4 *a*, interior of the same valve; 4 *b*, exterior of ventral valve; 4 *c*, interior of ditto.—J. W. S.

LEPTÆNA TRANSVERSALIS, Dalman.

SYNONYMS.—*Lept. transversalis*, Dalm., l. c. et auctorum; *L. duplicata*, Sow. in Sil. Syst., t. 22, f. 2; Geol. Journal, vol. i, p. 21 *a*.

The examination of numerous specimens of this common shell *in situ* have rendered it certain that the two species are respectively interior and exterior of each other. The species is distinct from *L. sericea*, the interior of the ventral (convex) valve being much more rugged in age; the muscular impressions and those of the vessels are very strongly marked, and the inner surface frequently rough with large irregular prickles.

L. sericea has the interior comparatively smooth, a forked central plate between the long pair of muscles, and less distinct vascular impressions; the prickles, too, are small, and in rows corresponding with the fine external striæ.

In the young state, a var. of *L. transversalis* has frequently longitudinal folds, about one to each stronger rib. This variety abounds in North Wales, but has not yet been observed in the districts under review: it should be termed *L. transversalis*, var. *undulata*.—J. W. S.

Orthis, Dalman.

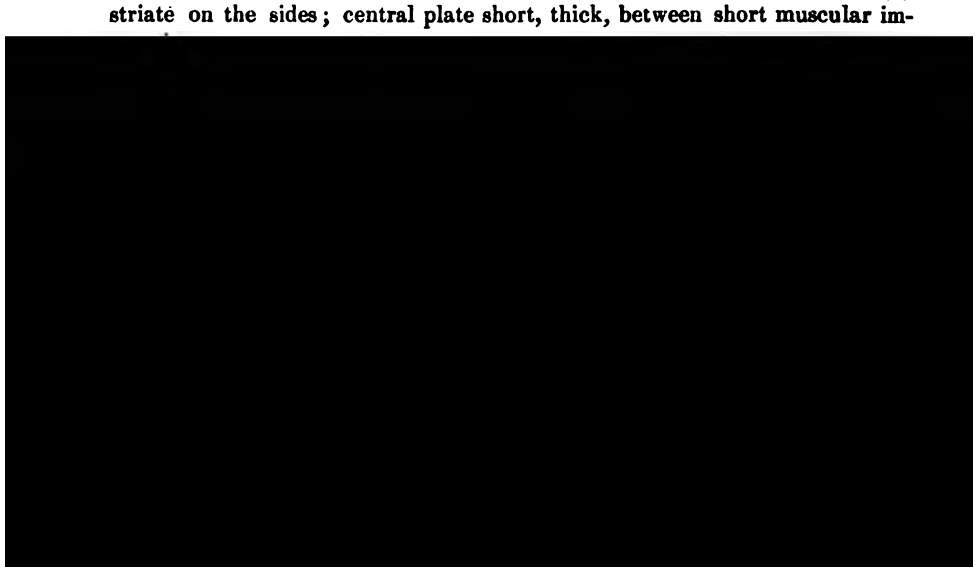
For reasons given under *Strophomena*, this genus must now be restricted to that very natural group represented by all Dalman's species, except the first, *O. Pecten*, characterized by—

Generic character.—A straight hinge line, and an area and foramen in both valves; ventral valve the enveloping one, with a pair of diverging teeth and hinge plates, dorsal valve with a diverging pair and one central tooth. (Moderately convex, often gibbous and inflated shells.)

Orthis inflata, Salter.

Synonyms.—*O. inflata*, Salter, Quarterly Geol. Journ., vol. i, 20 *a*, &c.

Specific character.—Semioval, wider than long, somewhat quadrate; ribs numerous, coarse, closely striated across with lines of growth, branched or forked twice (seldom more) in twos or threes, direct along the hinge line. Dorsal valve convex at the beak, then flat, or broadly depressed along the middle, the sides recurved; its area broadish, at right angles to the valve, foramen broad, open; teeth strong, compressed; hinge plates directed outwards at an obtuse angle; muscular impression square or doubly rhomboidal, divided by a sinus, and produced at the lower angles. Ventral valve strongly gibbous, a little emarginate in front; area narrow, vertical to the dorsal area; teeth at a right angle, central tooth rather thin, strongly striate on the sides; central plate short, thick, between short muscular im-



variety, in another, in Mr. Lyell's collection from Ohio, nearly circular; the medial tooth striate.

Now, except in the broad depression and general flatness of the dorsal valve, which is not convex or furrowed along the middle, and in the very angular shape and less prominent edges of the muscular impression in the flat valve, the English shell does not differ from the American. In Hall's full descriptions characters are mentioned which agree with our shell, but which Mr. Lyell's series is not sufficient to exhibit, and these bring the two species near each other. In var. *subquadrata* the (visceral) muscular impressions have the base straight, and the dorsal valve is "nearly flat," the ventral valve having a slight central depression. In *O. occidentalis* the furrow down the ventral valve soon vanishes, and the dorsal valve indents it. *O. sinuata* has the ventral valve a little elevated in the middle; the ribs in some are visible all over the interior surface, in others only at the margin. In fact, the passage of one of these forms into another may be seen in a handful of this Lower Silurian shell, so common in the Western states. Notwithstanding that the ribs of our shell are (generally, not always) coarser, and the dorsal valve and its muscles differ from the American species, we venture to predict that the two will be yet connected by intermediate forms.

Locality.—Coniston limestone, Westmoreland; also N. Wales, Lower Silurian.

Var. β RETRORSA, Salter.

REF.—Plate XXVII., figs. 3, 4.

Ventral valve gibbous, the centre rather raised. Dorsal flat, broadly depressed along the middle, edge not recurved; beak suppressed; area at an obtuse angle with the valve.

This variety, if it can be considered so, comes nearest the var. *subjugata* of Hall's descriptions; it is quite distinct from *O. anomala*, Schloth.

Locality.—Bird's-hill Quarries, North of Llandilo, in limestone.—J. W. S.

ORTHIS TESTUDINARIA, Dalman.

REF.—Plate XXVII., figs. 5—10.

SYNONYMS.—*O. testudinaria*, Dalman, Act. Holm. 1827, Pl. 2, f. 4. Hising. Leth. Suec., t. 20, f. 11 (*icon. mal.*). Sow. in Sil. Syst., t. 20, f. 9, 10. Bronn, Lethæa Geogn., t. 3, f. 21. *O. argentea*, Hisinger, t. 20, f. 15?

—— var. *tetragona*, Römer, Rheinisch, Uebergangsg, t. 5, f. 6 *a b*.

—— var. *ventroplana*, ib., t. 5, f. 6 *c, d*. *O. opercularis*, De Verneuil, Geol. Russ. t. 13, f. 2.

Our shell is —— orbicular, plano-convex, the ventral valve convex, marked by varices or periods of growth; surface striated by numerous thin raised striæ, interlined by others as the shell grows older; the striæ thinner than the interstices, which are granulated by close regular concentric

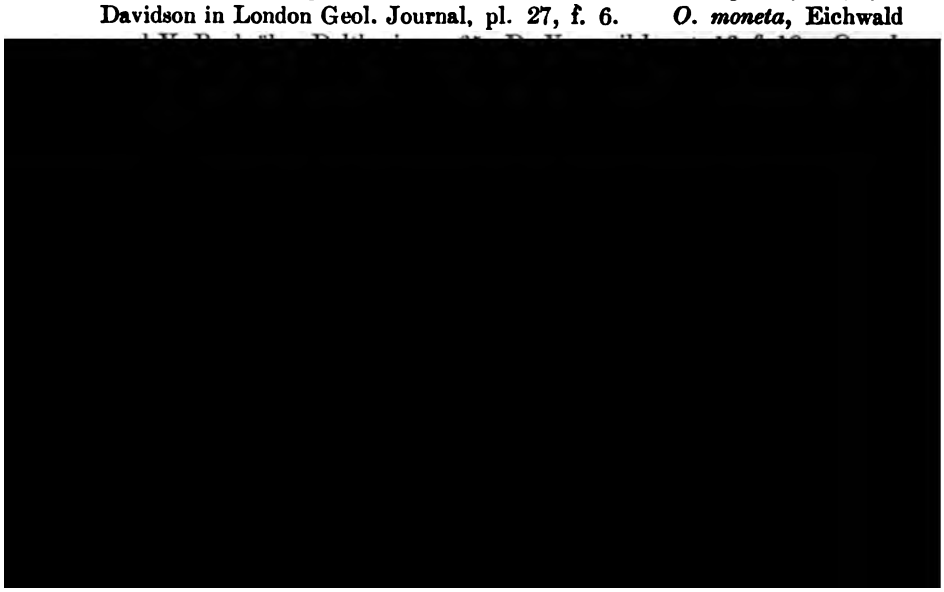
striæ; hinge line shorter than the width of the shell; area small triangular. Ventral valve gibbous near the beak, more gently convex afterwards; beak not prominent; teeth short, approximate above, diverging at 80°; hinge plates faint, parallel or diverging a little; muscular impressions together oval, oblong, narrow, divided by a faint broad bar. Dorsal valve flat or convex, and channelled along the middle, the striæ more regular, arching upwards all along the hinge line; teeth short, diverging at 70°, united to the short thick central plate, hinge plates none; central tooth small, short, thin. (Interior of both valves only striated near the margin).

Much longer than *O. elegantula*, from which small specimens may be easily distinguished by the remarkably granulated interstices of the striæ, the less convexity of the ventral valve, rounder not cordate outline (in var. *tetragona* quadrate); unequal striæ which turn up to hinge line, and near it have three or four faint ones between each; the less prominence and thickness of the teeth in both valves, and the absence of hinge plates, and a strong central tooth in the dorsal valve. The two species each vary much, yet not towards each other, they rather undergo a parallel series of variations, still retaining the essential peculiarities of form, striation, and internal structure. I have very little doubt that *Atrypa polygramma* is a large variety, but it is not safe to quote it, as the striæ are forked, not interlined, and are as broad or broader than their interstices; our fig. 10 is nearest to it.

Locality.—Variety with flat dorsal valve at Pant dwfn, Haverfordwest, and Pont-brennaraeth, Llandilo. The square var. at Pant dwfn, Panblewin, and Llwychgwyn; a small var. with distant striæ, at Llandilo. The convex variety, fig. 10, at Lann Mill.—J. W. S.

Orthis calligramma, Dalman.

Synonyms.—*O. calligramma*, Dalm. Act. Holm. 1827, pl. 2, f. 3. His. Leth. Suec. p. 71, pl. 20, f. 10. Von Buch, 1840, Mem. de la Soc. Geol. de France, vol. iv., pl. 11, f. 1. De Verneuil Geol. Russ., pl. 13, f. 7, 8, 9. Davidson in London Geol. Journal, pl. 27, f. 6. *O. moneta*, Eichwald



SPECIFIC CHARACTER.—As wide, or wider than long, very seldom marked with any varices of growth, radiated with numerous abrupt prominent squarish ribs, either simple or with shorter ones between, and with square furrows equal to the ribs; ribs often longitudinally and transversely striate; the furrows and ribs only visible a short way from the margin interiorly (abruptly prominent in the cast). Ventral valve always the more convex, and with a moderate subvertical area. Dorsal valve flattish, with a central shallow depression above; area moderate, vertical. Teeth in ventral valve compressed; foramen rather broad; hinge plates moderate, arched below, enclosing, except at the base, a rhomboidal muscular impression which is divided by a broad faint ridge; teeth of dorsal valve strong, with a small isolated hollow behind, each diverging broadly: central tooth long, linear, with a conical hollow on each side, connected with a thick central plate separating the sunk muscular impressions; lower pair with their upper edges distinctly marked; interior of both valves scabrous towards the ears.

I fear few students of Silurian fossils will be disposed to go with me in uniting all the above-mentioned forms, and yet a somewhat extended study of the species from various localities, has led to the conviction that they are variations of one typical form, which perhaps is best represented by *O. virgata*, Sil. Syst., varying as much on one side to the round few-ribbed *O. ovata*, as, on the other, to the expanded wings and numerous ribs of *Spir. plicatus*. In the multiplication of ribs, *O. Wallsalliensis* shows the extreme variation:—with respect to convexity, the two extremes are observable in *O. ovata* and *O. rustica*. In all the varieties with coarse ribs, longitudinal or transverse striæ, or both, are present. In all varieties the ribs have an abrupt rod-like aspect, the ventral valve is the more convex, the shape of the rhomboidal ventral muscles and the broad space between the dorsal teeth, which is bisected by a narrow central tooth, is similar: except in the extreme forms the outline is square, and the dorsal valve is in all the less convex, with a faint medial depression above; and there is a general character of similarity running through specimens from the same locality, which Mons. de Verneuil, in bringing together *O. ovata* and *O. orthambonites*, Von Buch, has been ready to appreciate. It is curious, that, in the Welch strata, almost all the varieties of the true *O. virgata* have more or less interlined ribs; and this prepared us to recognize the species in the usually more rugged form of *O. rustica*, and the interior confirms the idea. The rich collections of Messrs. Gray and Fletcher, at Dudley, contain the original specimens from which Mr. Davidson's figures were drawn, and an examination of these obliges us to differ from him as to their specific value. It is proposed to retain the following varieties, and we give a reference to the characteristic figure of each.

O. CALLIGRAMMA, var. OVATA, De Vern.

REF.—Geol. Russ., Plate XIII., fig. 9. Davidson, l. c., t. 27, f. 6.

Ventral area broad; hinge line very short, triangular; foramen narrow; ribs simple.

Passing through De Verneuil's fig. 7 *a* and 7 *c* into

O. CALLIGRAMMA, Dalm. (vera.)

REF.--Murch., Geol. Russ., Plate XIII., figs. 7 and 8 *a*, *b*.

Width equal to, or greater than, the length; ears not extended, foramen moderately broad, ribs simple.

O. CALLIGRAMMA, var. ORTHAMBONITES, De Vern.

REF.—Geol. Russ., t. 13, f. 8 *e*.

Width greatest, ears extended, foramen an equilateral triangle, ribs simple.

O. CALLIGRAMMA var. PLICATA, Salter.

REF.—*Spirifer plicatus*, Sil. Syst., t. 21, f. 6.

Much wider than long, ears much extended, foramen a right-angled triangle, ribs much interlined and crowded at the ears.

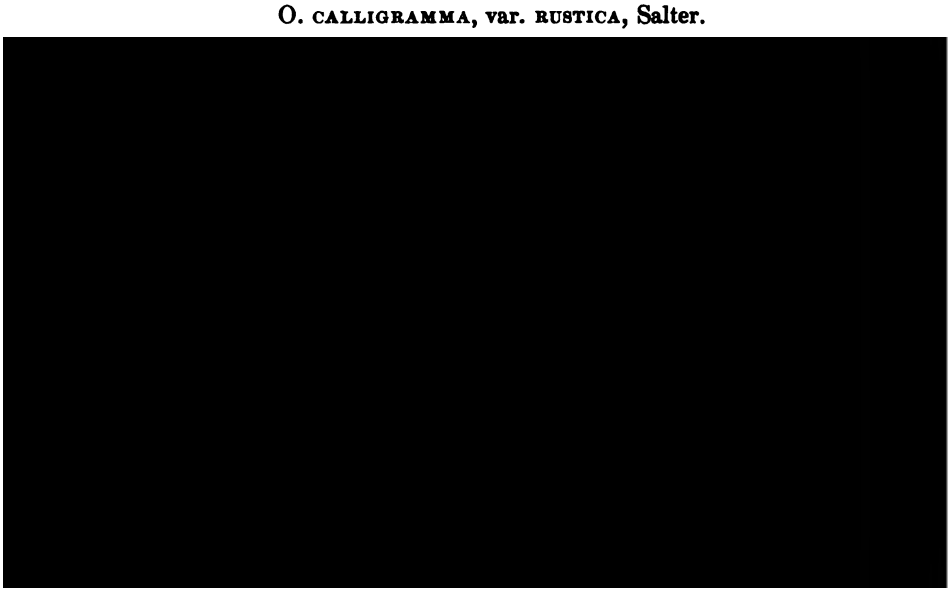
O. CALLIGRAMMA, var. WALSALLIENSIS, Salter.

REF.—Davidson, l. c., Plate XXII., fig. 9. [*O. grandis var*, Portl., l. c.?]

Squarish, width rather greater than length, ears not extended, foramen broad, ribs closely interlined and very numerous.

This var. appears intermediate between the many plaited vars. of *Sp. plicatus*, so common at Bala in North Wales, and

O. CALLIGRAMMA, var. RUSTICA, Salter.



The broad hinge-area, and elongate form approximate this to the var. *ovata*; some intermediate steps are however wanted before we could make out a circle of varieties.

Enough, however, may be gathered from this multiplied form and variety of one shell, which yet retains its own distinction from other and neighbouring species, to warn us that an extended study, such as a common species affords us, may often prevent the erroneous multiplication of specific names; twenty-nine different appellations have been given to this one variable fossil, though sixteen of these may be subtracted, as the specific names of Pander are acknowledged to be of no value. Still we are by no means to conclude that it is impossible to separate this from allied species: *O. flabellulum*, Sow., though like, is constantly distinguished by its undulations, not ribs, and by the reversal of shallow and deep valves as respects our shell, the dorsal, not ventral, being always the convex one; to this is added a striking difference in the teeth and muscular impressions. *O. Actonia*, likewise often confounded, is distinct by the concavity of the dorsal valve, and the sharp angular, often trifid ribs, the interior being also different from our shell, and the convexity of the valves again the reverse of *O. flabellulum*. These are combined as well as tangible characters, and it is for such we must seek in attempting to define species; till these be obtained it may be convenient to give each form a name, but we can never be certain that we are dealing with separate specific types, and can therefore deduce from them no fixed conclusions relative to their history or distribution.—J. W. S.

STROPHOMENA, Rafinesque, Blainv.

Published in 1825 by Blainville, and adopted by him from Rafinesque's previous paper. The genus was founded for a flattened shell, *S. rugosa*, allied to the American *S. alternata* of Emmons. *Orthis pecten*, given by Dalman at the head of the genus, appears to be the only one of his species which properly belongs to Rafinesque's group; there is no reason, therefore, why the older name should not be used, and all Dalman's genera be still retained. The generic character may be provisionally given;

GENERIC CHARACTER.—A long hinge line, with a linear area developed on the ventral valve only; the ventral valve furnished with a pair of widely diverging teeth and faint hinge plates; dorsal valve with a diverging pair, and an inner very prominent pair supported on the central ridge. [The central pair sometimes nearly fused into a thick callosity. Wide, flat, or gently bent shells, the dorsal or ventral valve the concave one.]

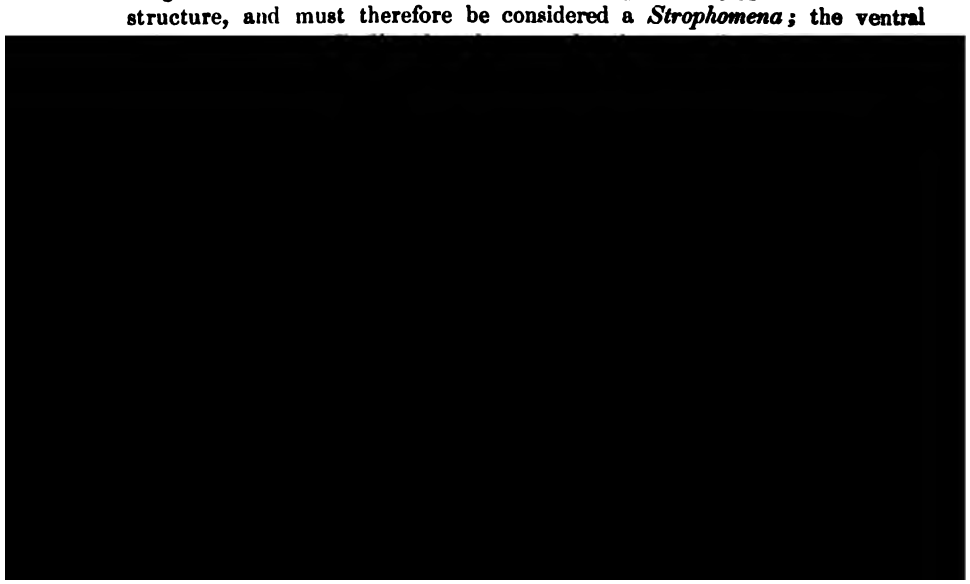
STROPHOMENA EXPANSA, Sow. sp.

SYNONYMS.—*Orthis expansa*, Sow. in Sil. Syst., t. 20, f. 14. *O. pecten*, b. t. 21, f. 9.

SPECIFIC CHARACTER.—Longitudinally half oval, a little wider than long; dorsal valve flat; ears not expanded, except slightly when young; hinge line

equal to the width; ventral valve radiated with fine raised threads, more numerous as the shell grows older, regularly interlined by three or five fine striæ, all crossed by still finer ones, and a few lines of growth at intervals; ventral teeth diverging at 100° or 120°, and from them interiorly a strong furrow reaches beyond the large ridgy muscular impressions, which are defined distinctly on their outer and basal edge, and extend half down the shell; hinge plates not stronger than the muscular ridges, diverging at 90° or 100°; muscles divided by a short double ridge above and a broad triangular one below; flat valve very finely and nearly equally striate; muscles divided into two broad ridges on each side of the short thick central plate, which extends only half or three-fourths down them; central teeth large, moderately diverging.

The surface along the hinge line is sometimes corrugated in oblique folds, and, I believe, in this state is the *O. rugifera*, Portl.; the raised threads, interlined by three or five fine ones, of which the central one afterwards becomes a strong thread, are arched upwards towards the sides, not radiated in straight lines; and the central triangular portion at the beak, marked off by the two diverging hinge plates, is raised up a little on the exterior. The most remarkable character resides in the muscular impressions, which are subrhomboidal and formed of numerous radiating ridges and furrows distinct and strong to the very end, while in *S. compressa*, the nearest ally, the upper edge alone of the muscles is visible, the muscles themselves hardly producing any mark. The interior, too, is smooth, not granulated in lines as in *S. compressa*; the vascular impressions, when present, radiate from the central ridge, a little below the base of the muscles, and curve outwards and upwards to the margin, forking two or three times; the space between the top one and the muscles pitted; the striæ are only visible round the edge internally. The hinge teeth in the dorsal valve are large and prominent, and supported on a thick central rib or plate, which divides the muscles: this is the structure of the allied species, *S. compressa* and *alternata*; there is also an accessory tooth, long and narrow, on each side of this pair. *Leptæna euglypha* has the same structure, and must therefore be considered a *Strophomena*; the ventral



We believe that from *S. pecten* on the one hand, to *L. euglypha* and *funiculata* on the other, there is no real generic distinction (*L. imbrex* and *Orthis grandis* certainly belong to *Strophomena*). But with respect to *L. sericea, transversalis*, &c., in which the dorsal valve is much modified, and the ventral valve very convex and enveloping the other like *Productus*, it may be advisable to keep them distinct, and apply the name *Leptæna* to this portion of Dalman's genus; like *L. depressa*, they have but one pair of dorsal teeth.

Locality.—Builth and Llandilo districts (in Lower Silurian); the best examples come from Meifod, near Welchpool, and Haverfordwest.—J. W. S.

S. COMPRESSA, Sow. sp.

SYNONYMS.—*Orthis compressa*, Sow. in Sil. Syst., t. 22, f. 12. M'Coy, Sil. Foss. Irel. p 29. *O. expansa*, var. *concentrica*, Portl. Geol. Rep., t. 37, f. 1, p. 452. *O. pecten*, p. 453. [perhaps *O. rugifera*, p. 453.] *O. Asmusi*, M'Coy, Sil. Foss. Irel. p. 28 [not of De Verneuil]. *O. concentrica*, ib. p. 29. *O. pseudopecten*, ib. pl. 3, f. 16.

SPECIFIC CHARACTER.—Squarish, considerably wider than long; dorsal valve flat; hinge line equal to the width; both valves finely striated, some striæ stronger than others, the furrows punctate in rows; concentrically rugate at intervals as the shell grows older; hinge teeth diverging at 130°; hinge plates moderately strong, continued from them along the upper edge of the suborbicular indistinctly marked muscular impressions, of which only the upper portions show any trace of furrows; muscles scarcely divided above, a faint thin ridge passing down between them; flat valve with but very faint central ridge or muscles; teeth four, distinct, the inner pair strong, moderately diverging. Interior of valves strongly scabrous.

It is to be confessed, that in general form and size and convexity this closely approaches the last, yet the striation is far more irregular, one or two lines between the larger striæ becoming larger in their turn,* and they are rendered more irregular in direction by the close set puncta that fill the furrows and make the interior rough with tubercles. The tendency to corrugation concentrically is a good habit character; but the chief distinction resides in the arrangement of the muscles,—in their greater divergence and consequent breadth above, and their being defined by the hinge plate on their upper edge only, not at all below as in the next species. This last, in many respects, resembles the present, but the muscles have a strong furrow along their inner edges extending to the base.

Locality.—The best specimens come from the Caradoc sandstone at Tortworth: they are abundant in Montgomeryshire, and also in the Tyrone schists, and at Grangegeeth, county Meath.—J. W. S.

* In some Wexford specimens this is hardly visible.

S. ALTERNATA, Sow. sp.

SYNONYMS.—*O. alternata*, Sow. in Sil. Syst. t. 19, f. 6.

This species resembles *S. expansa* in the striation of the ventral valve; but the larger striæ are not regularly interlined by groups of fine ones, except towards the ears in the young shell; the furrows are punctate, but with finer and more numerous dots than the preceding species, and the interior, of course, is more minutely scabrous; the chief distinction lies in the muscular impressions of the ventral valve, which extends two-thirds down the shell, and are separated apparently by a broad band, whose sides are formed by two regularly diverging strong furrows; the upper edge of the muscles, marked by the widely diverging hinge teeth of the dorsal valve, resembles closely the same part in *S. expansa*.

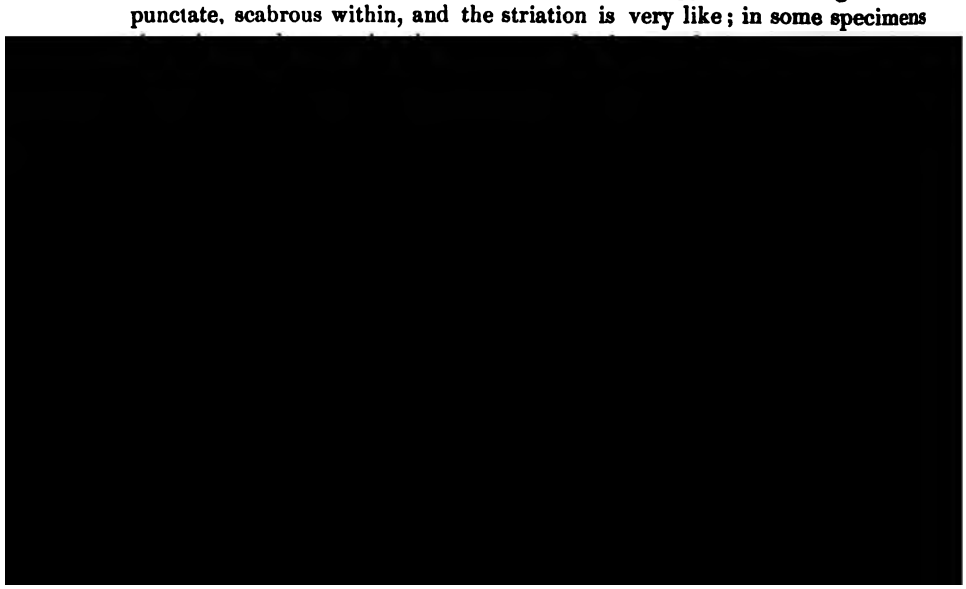
Having pointed out the characters by which this species is distinguished from *S. compressa*, we still believe it will be united with it by the discovery of intermediate varieties. *S. compressa* is evidently a common and widely spread shell, and such species always vary. The one before us, in occasional concentric rugæ, as well as in a less degree of punctation, approaches the last; and if it be a dwarf variety, the great extension of the muscles may be accounted for; as yet, however, we have no right to unite them, and it is better to make the distinctions clear, that we may not have the synonymy of these three allied forms confounded for the future. All three are Lower Silurian fossils.

Locality.—Common at Soudley, near Acton Scott, in the Hollies limestone [*S. expansa* is abundant in the sandstone quarries there], also Cardington, Shropshire.—J. W. S.

S. FILOSA, Sow. sp.

SYNONYMS.—*Orthis filosa*, Sow in Sil. Syst. t. 13, f. 12.

More nearly allied to *S. compressa*, than would appear at first sight; it is punctate, scabrous within, and the striation is very like; in some specimens



Our shell is nearly allied to *S. pecten*, from which, after careful study, we still keep it separate. Independently of the projecting points of the ribs and their greater number and sharpness, the small size appears constant; the dorsal valve grows flatter, not more convex, as it grows older; the opposite valve is slightly convex as usual, then flat, and the ribs are interlined by smaller ones almost from the apex, a character which is very unlike *S. pecten*.

Locality.—Craig-y-garcyd, Usk.—J. W. S

S. PECTEN, Linn. sp.

SYNONYMS.—*Anomia pecten*, Linnæus, Syst. Naturæ, 12 ed., p. 1152. Dalm. Act. Holmiæ. 1824. *Orthis pecten*, ib. 1827, t. 1, f. 6, [not of Murchison]. Davidson in Lond. Geol. Journal, vol. 1, pl. 13, f. 18 to 23. *O. Asmusi*, De Vern. Geol. Russ. Pl. 10, fig. 17, 18.

Well distinguished from all allied species, by its transverse form and regular thread-like radii; these are continued in rays of nearly equal thickness from the beak to the front, and regularly interlined by similar ones, as the shell enlarges. Some varieties have the ribs much closer than others.

From *S. applanata* last described it differs in the ribs not projecting into teeth on the margin; and, in the wide form, the hinge plates in the dorsal valve diverge at 110° or more, not at a right angle; the teeth are closely approximate without a central one, as usual in this section; in older individuals they appear to unite in one prominent mass, and fill up the deltidial opening.—J. W. S.

SPIRIFER PLICATELLUS, Linn. sp.

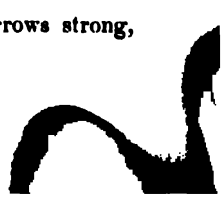
SYNONYMS.—*Anomia angulis dilat.*, Mus. Tessin, t. 5, f. 7? *A. plicatella*, Linn. Syst. Naturæ, ed. 12, p. 1154, [not of Dalman]. *Delthyris cyrtæna*, Dalm. l. c. t. 3, f. 4. Hising. l. c. t. 21, f. 4.

This is the common form of the species, and is easily recognized in Linnæus' description "longitudinally striated along with the ribs, lateral angles expanded." It is very common in this form in the Wenlock limestone; the ribs are divided by undulations rather than sharp lines, and there is every passage from a strongly ribbed and furrowed shell to the smooth variety figured in the Sil. Syst., and this again contracts in width, till the hinge line is lost, and it assumes the shape of *S. glabra* of the Carb. limestone, the beaks being closely approximate and incurved; on the other side it varies with a wider and wider area, till the depth is greater than the length of the valve, including in its variations the following species.

S. PLICATELLUS, var. INTERLINEATUS, Salter.

SYNONYMS.—*S. interlineatus*, Sow. in Sil. Syst. t. 5, f. 6.

Longer than broad, hinge line short, beaks approximate, furrows strong, sharp.



S. PLICATELLUS, (true.)

REF.—Dalm., l. c., t. 3, f. 4.

Wider than long, hinge line expanded, beaks moderately distant, furrows more or less distinct.

S. radiatus, Sow. Min. Conch. connects this with

S. PLICATELLUS, var. GLOBOSUS, Salter.

About as wide, or a little wider than long, hinge line very short, beaks approximate; furrows none. [Very gibbous].

Abundant at Dudley; some fine specimens are in Messrs. Gray and Fletcher's collections.

S. PLICATELLUS, var. EXPORRECTUS, Salter.

SYNONYMS.—*Cyrtia exporrecta*, Hising, l. c., t. 21, f. 2. *Anomites exporrectus*, Wahl. in Act. R. S. Ups. vol. 8, p. 64.

Cardinal area excessively enlarged longitudinally, foramen closed above and below, frequently produced into a rostrum in the middle. Longitudinally striate, no furrows.

This occurs at Dudley frequently; it can be easily traced into the next variety.

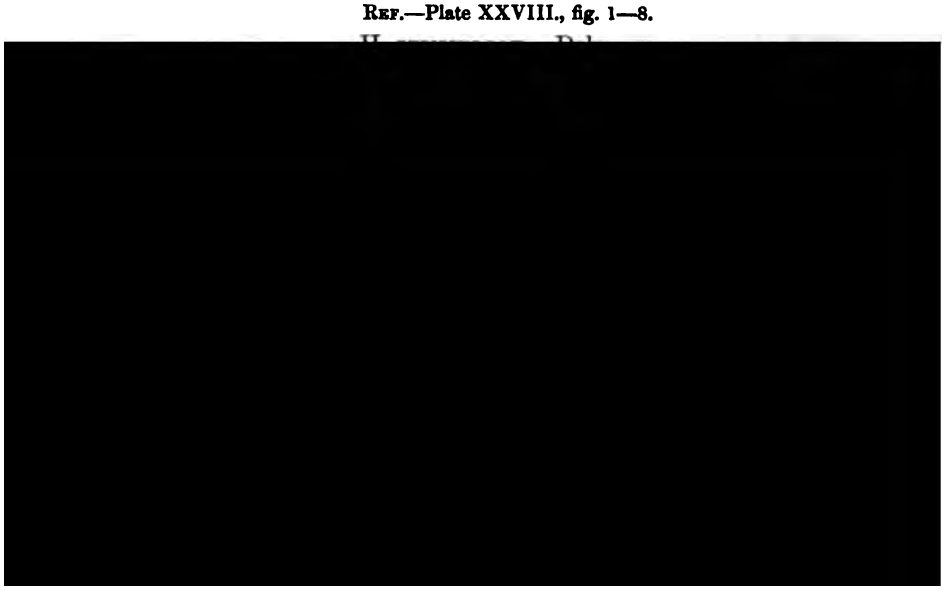
S. PLICATELLUS, var. TRAPEZOIDALIS, Salter.

SYNONYMS.—*Cyrtia trapezoidalis*, Dalm. l. c. t. 13, f. 2; Hising. Leth. Suec. t. 21, f. 1; Bronn. Leth. Geogn. t. 3, f. 3. *Spirifer trapez.* Sow. in Sil. Syst. t. 5, f. 14.

Cardinal area greatly enlarged, foramen not closed below, longitudinal striæ very fine and even, sometimes obsolete.—J. W. S.

HYPOTHYRIS. Phillips. Morris, &c.

REF.—Plate XXVIII., fig. 1—8.



The above specific character, though long, is necessary to distinguish this common shell from other Silurian species, and especially from *T. lacunosa*, with which Mr. Sowerby had cautiously united it.

It is, however, a much smaller and more delicate shell, never has the strong ventral and dorsal sinus in the young state, and the middle does not rise abruptly and bring its plaits to a level as in *T. lacunosa*, but has them on the sides, as well as top of the curved elevation; the sinus is very deep on the front margin, but it is more by suppression of the central ribs than by their elevation, a very frequent character of *Terebratulæ*. The name is adopted from a Swedish specimen so labelled, but from what work of Dalman's it is adopted, we do not know. We recognize *T. neglecta*, from the Lower Silurian Rocks of Llandovery, for this species; it occurs at other places in Lower Silurian Rocks.

Locality.—Abundant *everywhere* in Upper Ludlow rock and the tile-stones, in company with *Chonetes sarcinulata*; the range of our shell is also an extended one, for it is found in Wenlock strata rarely.—J. W. S.

H. BOREALIS, (Schloth.) Von Buch.

REF.—Plate XXVIII., fig. 9—14.

SYNONYMS.—(*Anomia lacunosa*. Linn. Syst. Natur. 12. ed. 1152, Mus. Tessin. t. 5, f. 6?) *Terebr. lacunosus*, Schloth. Nachtr., t. 20, f. 6, (not of Wahlenberg, Dalman, or Hisinger). *Anomia plicatella*, Wahl. 1821, Act. Soc. Upsal, &c., vol. 8. 67. *Terebrat. plicatella*, Dalm. Act. Holm., 1827, t. 6, f. 2. Hising. Leth. Suec. 80, t. 23, f. 4. De Vern. Geol. Russ. 84. *T. borealis*, Schloth. Catal. p. 65, n. 88, (*vide* Von Buch.) Von Buch. über Terebr. 67. *T. lacunosa*, Sow. in Sil. Syst., t. 12, f. 13a. *T. diodonta*, Dalm. l. c. t. 6 f. 4; Hising. l. c. t. 23, f. 6. *T. bidentata*, Sow. in Sil. Syst. t. 12, f. 13a, (not of Dalm. l. c. t. 6, f. 5; His. l. c. t. 23, f. 7?)

SPECIFIC CHARACTER.—Subtriangular with the beak produced, wider than long, convex, the dorsal valve most so; sinus deep, the dorsal fold *abruptly* raised, even in the young, with two, three, four, or even six, strong sharp ribs, or generally two forked ones, their teeth not long in front; from three to six ribs on each side; centre of ventral valve deeply depressed, with one central rib at first, then three, seldom two or four; its sides smooth and concave near the beak; foramen moderate, beneath an overhanging beak; teeth strong; deltidium small. Surface with strong lines of growth.

Very common in the Wenlock limestone, and conspicuous, even in its young state, by the two raised dorsal ribs and the deep furrow in the ventral valve with its single rib. If this number be retained, it becomes *T. diodonta*, Dalm., and perhaps, even *T. bidentata*, ib., may be the young of it, but with respect to the former, I am quite sure it is only a variety.* The shell under consideration varies much in the number of plaits, and in their depth and thickness; they are generally sharp and strong, but do not possess elongate

* Dalman has hinted the probability of this; the *T. bidentata*, Sil. Syst., is a synonym of *T. diodonta*. There are more extreme varieties yet unfigured.

points or teeth in the sinus, as the preceding species does; and the sinus is deep by the elevation, not suppression, of the ribs on the dorsal fold. The surface is scaly, or marked strongly with lines of growth; the shell is frequently 1½ inches wide.

CRINOIDEA.

Cyathocrinites ? macrostylus, Phillips.

Specific character.—Column extremely slender, very much elongated, composed of very numerous joints.

Locality.—Near Stoke Edith in the Woolhope district.

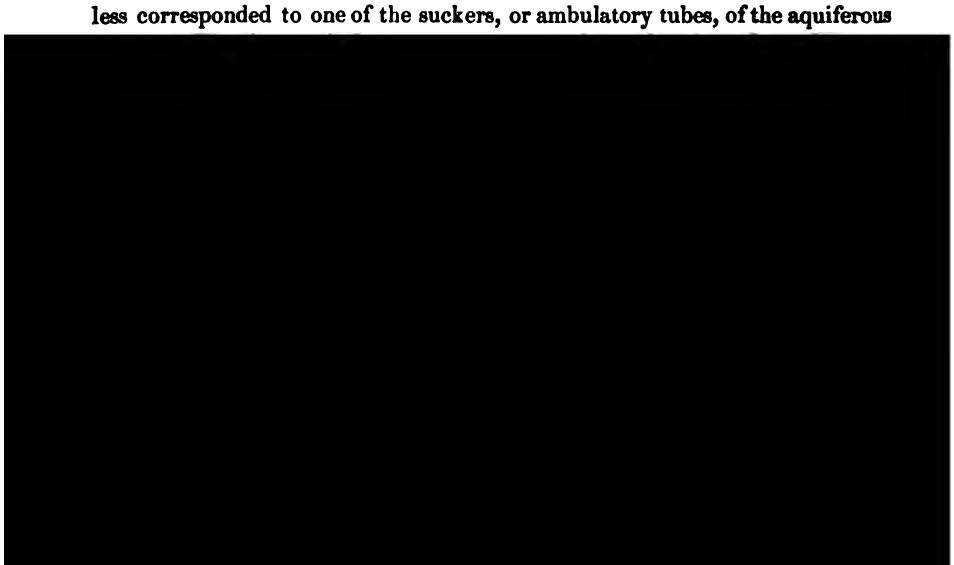
Remarks.—Only the column is known; but its extraordinary smallness, compared to the length, deserves to be recorded. The length has been seen to be as much as two feet, and the diameter less than a quarter of an inch. As the name can be only provisional, it is not considered necessary to give a figure.—J. P.

ECHINIDA.

Palechinus Phillipsiæ. Forbes.

Ref.—Plate XXIX.

Ambulacra composed of four series of poriferous plates, those of the two inner series cuneiform and shorter than the two outer, which meet and alternate without being separated by any ambulacral plates. The plates of the outer or broader series, are transversely linear-oblong, and slightly cuneate, in consequence of the intervention of those of the inner series. Each plate, whether inner or outer, is perforated by a pair of rather large pores, which pair doubtless corresponded to one of the suckers, or ambulatory tubes, of the aquiferous



Beacon, by Miss Phillips, to whose honour I have the greatest pleasure in dedicating it, as a slight memorial of the service rendered to British Geology by the observation of this conglomerate. It is certainly one of the most interesting fossils which have been discovered for many years, since in it we gain a link whereby to connect still closer the Silurian with the Carboniferous systems, seeing that hitherto the genus *Palechinus* has been known only in the latter. The avenues differ in structure considerably from those of any of the Siluran species figured and described by Mr. M'Coy, and possibly indicate a subgeneric difference. The specimen is unfortunately very imperfect, but at the same time. unquestionable.—E. F.

FAVOSITES RAMULOSA. Phillips.

SYNONYMS.—*Calamopora spongites*. Goldfuss, t. 64, f. 10. Murchison Sil. Syst. t. 15 bis, f. 9.

SPECIFIC CHARACTER.—Ramose; the branches varying in diameter, but always having a circular section; the surface covered with minute approximate round or subangular cells.

Locality.—Common, especially in the Llandilo District.

Remarks.—This coral appears to be different from *F. spongites*, to which it is linked by Goldfuss, by its general habit of growth, and the form of its small cells. Mr. Lonsdale appears to have reserved it for farther consideration (Sil. Syst., p. 684). It appears to us more similar to *F. polymorpha*.—J. P.

FAVOSITES? FAVULOSA. Phillips.

REF.—Plate XXX., fig. 3.

SPECIFIC CHARACTER.—Expanded into broad lamelliform disks; composed of very numerous cells laterally adherent, and *systematically unequal* in diameter, owing to the enlargement of special groups of cells, which are so arranged in the disk, that the centres of enlargement are about 12 cells apart. Diameter of the largest cells, $\frac{1}{30}$th, of the smallest $\frac{1}{170}$th of an inch.

Locality.—Lann Mill, in the Llandilo Limestone Series. The stone is decomposed to "rotten-stone," and is easily removed.

Remarks.—This beautiful little coral reminds us of the structure of *Heliopora*, Blainv. (*Porites*, Lonsdale) and *Stromatopora*, groups in which certain special centres of enlargement appear amidst a minute honeycomb tissue, full of transverse dissepiments (see the drawings of *Porites* and *Stromatopora* in Sil. Syst. and Pal. Fossils of Devon). Professor Forbes has suggested to me that the enlarged cells in the fossil before us may be regarded as *fertile*, amidst groups of infertile cells. Applying this consideration to the view abovementioned, we should see in the species under consideration the analogue of a young *Heliopora* with undeveloped *Polypi*; and in fact I have seen specimens of *H. pyriformis* which, in their young state, resemble this, excepting that in them the small cells which separate the larger ones are equal, and much less numerous. In the little coral we are examining, the cells

gradually grow less and less for some distance from the centres of enlargement, and do not so suddenly change from large to minute as in the peculiar specimen of *Stromatopora polymorpha* figured by Goldfuss (Pl. 64, f. 8 f), to which, however, its resemblance is evident.

Under the microscope the cell walls appear double; and when wider than usual, the intercellular space is (rarely) seen to be porous, or even partitioned in minute compartments; transverse partitions appear, but I do not see, with certainty, any foramina leading from cell to cell. The coral is siliceous, a rare circumstance in Silurian rocks, except in the western regions, nor there common, except in particular beds.—J. P.

PLANTS.

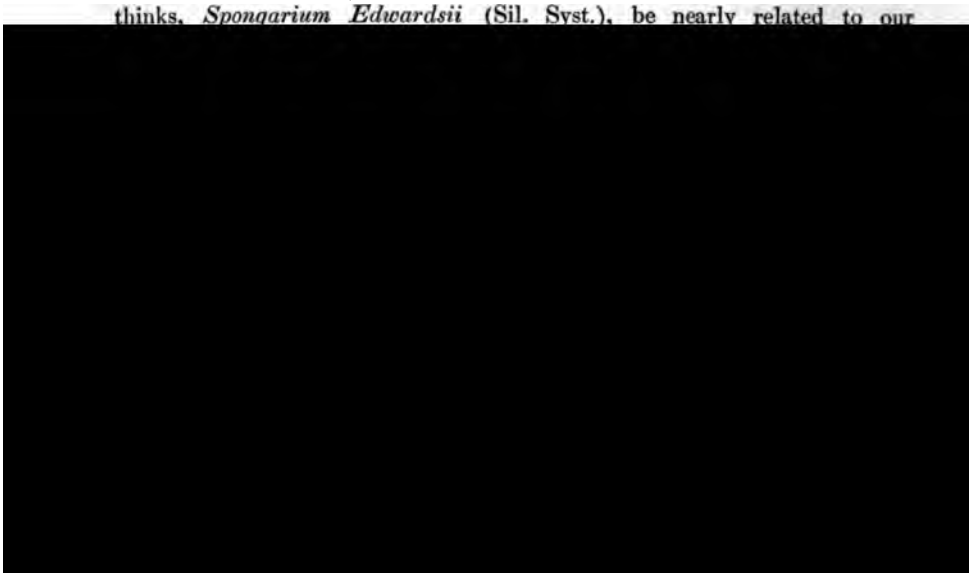
ACTINOPHYLLUM PLICATUM. Phillips.

REF.—Plate XXX., fig. 4.

SPECIFIC CHARACTER.—A thin nearly flat oval disk, revolute at the edge, and radiated from a central oval space (of attachment ?), the rays once or twice bifurcating so as to make in all 36, each crossed by distinct transverse (concentric) furrows.

Locality.—Perton, near Stoke Edith, in the Woolhope District, at the junction of Upper Ludlow with Old Red.

Remarks.—We may compare this unique fossil to internal plates of radiated animals like *Velella* and *Porpita*, or to the singular marine forms of *Acetabulum* and *Polyphysa*, now referred to the vegetable kingdom. Dr. W. Hooker and Professor Forbes concur in preferring the latter analogy; and their opinion, after the best examination which is in my power, appears to be the most probable. *Acetabulum* (*Acetabularia*, Lamx.) would thus become represented by at least one Palæozoic form; but if, as Mr. Salter thinks, *Spongarium Edwardsii* (Sil. Syst.), be nearly related to our



INDEX

TO THE SECOND VOLUME.—PART I.

Abberley district, 145; elevations in, 145; Palæozoic strata of, 146–148; relative positions, dips, faults, undulations, reversals, &c., with diagram, 146–154; greenstone dyke, 156, 157; coal series, 158–160; mesozoic strata, 160; conglomerate hills, Sir R. Murchison's view of those hills, 162; general comparison of the Abberley and Malvern Hills, 163; localities in, 329
Acanthopyge, 339
Acervularia, 303
Acetabularia, 386
Acidaspis, 235, 348
Actinoceras, 354
Actinocrinites, 300
Actinodonta, new genus, 268, 366
Actinophyllum, 312, 386
Addison, W., his paper on the medical topography of Malvern, 3
Agassiz, his classification of fishes, 226.
Agnostus, 235–351
Aikin, A., his paper on the Wrekin and coal-field of Shropshire, 2
Alfrick Pound, sections here, 76
Allorisma, 359
Alveolites, 303
Amphion, 341
Ampyx, 235, 350
Analysis of Malvern waters, 17; May Hill limestones, 186
Annelida, remarks on, 227; lists of, 227; tables of, 231, 232, and remarks
Anomia plicatella, Linn., 381; A. lacunosa, *ib.*, 383
Arca, 268, 366
Arcacidæ, 268; most numerous in the Malvern district, 273
Asaphi, 338
Asaphus, 235
Association of mineral and organic phenomena, 222
Atrypa, 276; A. reticularis (A. prisca), most abundant and widely distributed of Silurian shells, 296; largest in Aymestry rock, 300
Aulopora, 303
Avicula, 269, 367; A. retroflexa, most widely distributed, 272
Aymestry rock (Malvern), character of surface; range, dips, anticlinal and synclinal dips; appearances at Ledbury, Eastnor, and Hale's-end, 91–94; Abberley, 148; Woolhope, 172

Banded traps, diagram, 45
Bartestree dyke, 180
Battus, 352
Bellerophon, 253, 356
Beyrichia, 234, 351
Biology, 208
Black shale of Malvern Hills, 26, 54; figures of its fossils, 55
Bone bed, Pyrton Passage, 226
Bowman, John, his papers on the Vale of Llangollen, &c., 4
Brachiopoda, 369; lists of, 275; tables and discussions, 294; great range of depth, 296; species characteristic of Upper and Lower Silurian. 299; most widely distributed species of, 296, 298; appear in the oldest strata, 296
Brand's Lodge, beds near it, 62
Bransill Castle, traps at, 56
Brecciated trap, diagram, 44
Bricks burnt from Wenlock shale, 76
Brockhill Dyke (Abberley), 156
Brockhill, Malvern, 65
Builth district, 216; its fossils examined by Mr. Salter, 225; Localities in 327
Burmeister, referred to, 234

Caermarthen district, 216; localities in, 32
Calamopora, 385
Calymene, 236, 341; wide distribution of C. Blumenbachii, 242
Caradoc, conglomerate (Malvern), 57–59; organic remains, 61; discovery of the shelly conglomerate, 66–68; sandstone, 61; found east of Swinyard Hill; enclosed in trap at the Wych, 64; stained red at Howler's Heath; fossils, 64, 65; (Abberley), 146; (Woolhope), 167; (May Hill), 182
Carboniferous deposits of Malvern, 104; coal of Boulsden, &c., its position under new red and conglomerate, illustrated by diagrams, &c., probable extent of, 108; (Abberley) 150–152, 158–160
Cardigan district, 216; localities in, 321

Cardiola, 265
Carpenter, W., M.D., structure of Pleurorhynchus, 359
Caryocystites, 301
Caryophyllia, 303
Catenipora, 303
Centres of life, 206, 209, 318, 321
Cephalobranchiate annelida, 227
Cephalopoda, 246; remarks on, 246; lists of, 247; tables and discussions, 251
Cephalopoda, 352; Lower Palæozoic, arrangement of, 246; rare in Llandilo limestones, 253
Ceraurus, 348
Ceriopora, 304
Cheirurus, 236–345
Cleidophorus, 264, 268
Climate of Malvern, 18
Clincher's Mill, 76, 77, 79
Clymenia, 353
Colwall Copse, 76–80
Comparison of the Abberley and Malvern Hills, 163
Composition and origin of the Malvern rocks, 39
Concretionary structures, Wenlock shale, 75; Wenlock limestone, 78
Conglomerate of Haffield, 111; origin of conglomerate, 125; of the Abberley Hills, 160; its origin discussed, 161, 162
Conocephalus, 341
Conocoryphe, 341
Conrad, Mr., 264, &c.
Conularia, 255
Conybeare, Rev. J., on the Geology of Malvern, 3
Cornulites, an annelide, 227, 228; wide distribution of; geological duration, 231
Corydocephalus (Hawle and Corda), 340
Country surrounding the Malvern Hills, 20–23
Cowley Park, 37; remarkable section at, 37, 76
Crew's Hill, 76
Crinoidea, 300, 384
Crustacea, remarks on, 233; lists of, 234; ting, 64; the shelly Malvern conglomerate, 67; referred to, 68, 124, 200, 201, 217, 221, 225
Diagrams (Malvern Hills), 7, 10; gravel pit, 15; bedded structures, 25; contact with trap, 27; chlorite vein, 33; Cowley Park, 37; Abberley syenite, 38; felspar veins, 42, 43; brecciated trap, 44; granular trap, *ib.*; banded trap, 45, 46; gneiss, 48; portion of Malvern Hills, 50; vertical section, Malvern, 51; trap near Hollybush, 57; map, 60; Caradoc beds in trap, 64; conglomerate and trap, 67; joints, 72; reversed beds of Worcester Beacon, 73; at Alfrick Pound, 76; flexures and faults in Wenlock lime, 82, 83; map, 84–87; flexures in Aymestry rock, 92; coal series, 105, 106, 108, 109; mesozoic strata, 111; undulations of new red, 118; junction of new red and Palæozoic strata, 119, 120; structure of Keüper, 121, 122; of old red sandstone, 131; map of flexures, 136; illustration of flexures and fractures, 137, 139, 140, 142, 143
Diagrams (Abberley), 7; section at Fetlock's Farm, 147; Ankerdine, 149; quarry near Knightsford Br.; conglomerate and coal on old red; Silurian between old and new red, 150; series of faults in new red, 151; flexures and reversals, *ib.*; theoretical explanations, 152; reversals, 153; theoretical explanations, 154; greenstone dykes, 156, 157
Diagrams (Woolhope), transverse section 7, 167; plan of limestone, 171; contortions, 172; joints, 173; the Wonder, 177
Diagrams (May Hill), transverse sections, 7, 182; surface of Caradoc conglomerate, 183; section of the Woolhope series, 184; Wenlock limestone, 185, 186; fault, 188
Diagrams (Tortworth) of new red and Palæozoic beds, 193; transverse section of district 7, 195; position of old red and magnesian conglomerate, 198; (Usk), transverse section 7, 200.

Abberley district, 147; in Woolhope district, 165
Emmerich, Dr., referred to, 333
Encrinurus, 237, 342
End pressures of strata, 143, 144, &c.
Endosiphonites, 353
Exomphalus, 257, 356
Eschara, 303

Fair Oaks, Caradoc beds here, east of the Malverns, 62
Faults, 7, 135, 142, 143, &c., 166, 168, 171, 172
Favosites, 305
Felspathic veins, 32; diagrams, 42, 43
Fenestella, 307
Fish-beds of Gamage, 178; Pyrase, 192, 225
Fishes, remarks on, 226
Fitton, Dr., article on Silurian system, 4
Flexures of strata, 7, 134, 136, 140, 141, &c.
Forbes, Professor E., referred to, 219, 225, 386; description of Ampyx, 350; of Palechinus, 384
Fossils, lists of, 61, 64, 65, 69, 73, 74; discussions relating to, 74, 75, 88; Upper Ladlow, 100
Fowlet Farm, traps at, 56
Freshwater district, strata of, 216, 218; localities in, 322
Fucoides, in Malvern, 312

Ganoid fishes, 226
Gasteropoda, 356; remarks on, 256; lists of, 256; tables and descriptions, 262
General remarks on the Palæozoic districts, 206
Geographical distribution of Lower Palæozoic life, 213, 316
Geological distribution of Lower Palæozoic life, 213, 316
Gneissic structure, diagram, 48; gneiss series, 50
Golden Grove, strata at, 221
Gold Pits, vein, green, 31
Goniophora, 267; proposed for Cypricardia cymbæformis, 264
Goniophora cymbæformis, widely spread, 272
Gorgonia, 308
Gould, Dr., referred to, 214
Granitic group, 42
Granular trap diagram, 44
Griffith, R., referred to, 197
Graptolithus, 308
Gullet-wood Valley; sandstone and conglomerates, on a narrow band of syenite, 29
Gunwick Mill, Caradoc sandstones here, 69

Hall, his genera referred to, 264, &c.
Harpides, 348
Haverfordwest districts, strata of, 216-219; localities in, 522
Hawle and Corda, new work on trilobites, 335
Hemicosmites, 301
Henslow, Professor, his description of Argessa, 5
Herefordshire Beacon, views of; felspathic rocks in the eastern part; disturbed strata on the west of; Silurian beds on its eastward slope near Wind's Point, 30, 31
Heteropoda, 258
Heteropora, 309, 356
Hollybush Valley, 28; lowest sandstone of the Malvern hills here, 28
Hollybush sandstone described, 31; in contact with trap, 37; traversed by dykes, 38; organic remains, 38
Homalonotus, 338
Hooker, Dr. J., referred to, 225, 386
Higgins, W., his paper on geological dynamics referred to, 143
Horner, L., his paper on the mineralogy of the Malvern Hills, 42; referred to, 64
Horse-shoe Farm, 197
Howler's Heath, Caradoc beds at, 57, 63
Hyperbolites, 301
Hypothyris, 279, 382

Illænus, 238, 338
Inferences on Palæozoic fossils, 320
Ireland, south of, its geological movement united with that of Malvern, 8
Inoceramus, referred to Mytilus, 364, 365
Interposed traps described, 55; diagram, 57; marked on map, 60
Introductory view; boundary of the Palæozoic districts; elevation, flexure, and fracture of strata, in the several districts; extension of these movements to Wales and Ireland, 5

James, Capt., referred to, 68
Jukes, J. B., referred to, 296

Keys-end Hill, 23 *et. seq.*; strata which surround it; many trap bosses near it; its composition and structure; diagram, 25; valley north of it with black shale, 25
Keyserling, Count, 64
King, W., his genera referred to, 264; Allorisma, 359; Strophomena, 378

Lamellibranchiata, rare in Llandilo limestone, common in Upper Silurian rocks, 274
Lamellibranchiata, remarks on, 263; lists of, 265; tables and descriptions, 272, 359
Lann Mill, 220
Leptæna, 281, 371
Lichas, 238, 339
Life, centres of, 206, 209, 321; remains of in Palæozoic strata, 208
Limaria, 309
Lindsway, 219
Lingula, 275, 369
Little Malvern, structures in road above it, 32
Littorina, 258

Lituites, 250, 352
Llandilo district, 216; localities in, 324; peculiarly rich in crustacea, 273
Llandewi Velfrey, 220
Llandovery, localities near, 326
Llangadoc, strata at, 220, 221
Local creation of species, 318; local transformation of species, 318
Localities, lists of, 321
Lower limestone shales (May Hill), 189
Lower Ludlow shales (Malvern), composition, balls, bands, nodules, brick-yards; range, extent, and particular phenomena, 89–91; (Abberley), 147; (Woolhope), 172
Lower Silurians, their upper boundary at Malvern discussed, 73, 75
Loxonema, 258
Ludlow Rocks, May Hill, 187; Tortworth, 191; Usk, 203
Lumbricina, 227
Lyell, Charles, referred to, 214

M'Coy, discovery of the true nature of Beyrichia, 351
——— new genus Trinodus, 351
M'Leay, W. S., his arrangement of annelida, 227; crustacea, 234.
Malvern district, 216; localities in, 329; etymology of, 9
Malvern Hills, seen from the south, 9; seen from the north, 21; views in, 30, 31, 35. *Physical geography:* passes across them, 9; diagram of, 10; survey of the several hills and passes, 11, 12; extent of horizon, 12; character of surface, angle of rest, detritus of, 13, 14; calculation of waste, no glacial furrows on, moss agates, &c., in Severn gravel, 14, 15; local gravel, 15; summit of drainage, level of the springs, temperatures of springs, analyses of springs, 16, 17; agricultural character, climate, table of temperatures, &c., 17, 18; ancient camps, tables of elevations of the Malvern Hills, 19, 20. *Country surrounding the Malverns:* its elevation above the sea, 20, 22; peculiarities of the Malvern Hills, 22; geological structure, 23; faults, 24; dykes, 25; trap, 26; syenitic rocks, 27; gneiss, 28; Malvern Hills, 29; Herefordshire Beacon, 32; Worcestershire Beacon, 33; Raggedstone, 34; Hollybush Hill, 35; Midsummer Hill, 36; Eastnor Park, 37; Ledbury, 38; Malvern Wells, 39; Colwall, 40; Cowleigh Park, 41; Malvern, 42; Great Malvern, 43; Malvern Link, 44; Barnard's Green, 45; Storridge, 46; Welland, 47; Upton, 48; Powick, 49; Worcester, 50; Hanley Castle, 51; Upton, 52; Tewkesbury, 53; Ripple, 54; Tirley, 55; Ashleworth, 56; Hasfield, 57; Gloucester, 58; Cheltenham, 59; Bredon Hill, 60; Bredon, 61; Eckington, 62; Pershore, 63; Evesham, 64; Broadway, 65; Chipping Campden, 66; Blockley, 67; Moreton-in-the-Marsh, 68; Stow-on-the-Wold, 69; Bourton-on-the-Water, 70; Northleach, 71; Cheltenham, 72; Cleeve Hill, 73; Winchcombe, 74; Tewkesbury, 75; Malvern, 76; Great Malvern, 77; Malvern Link, 78; Barnard's Green, 79; Storridge, 80; Welland, 81; Upton, 82; Powick, 83; Worcester, 84; Hanley Castle, 85; Upton, 86; Tewkesbury, 87; Ripple, 88; Tirley, 89; Ashleworth, 90; Hasfield, 91; Gloucester, 92; Cheltenham, 93; Bredon Hill, 94; Bredon, 95; Eckington, 96; Pershore, 97; Evesham, 98; Broadway, 99; Chipping Campden, 100; Blockley, 101; Moreton-in-the-Marsh, 102; Stow-on-the-Wold, 103; Bourton-on-the-Water, 104; Northleach, 105; Cheltenham, 106; Cleeve Hill, 107; Winchcombe, 108; Tewkesbury, 109; Malvern, 110; Great Malvern, 111; Malvern Link, 112; Barnard's Green, 113; Storridge, 114; Welland, 115; Upton, 116; Powick, 117; Worcester, 118; Hanley Castle, 119; Upton, 120; Tewkesbury, 121; Ripple, 122; Tirley, 123; Ashleworth, 124; Hasfield, 125; Gloucester, 126; Cheltenham, 127; Bredon Hill, 128; Bredon, 129; Eckington, 130; Pershore, 131; Evesham, 132; Broadway, 133; Chipping Campden, 134; Blockley, 135; Moreton-in-the-Marsh, 136; Stow-on-the-Wold, 137; Bourton-on-the-Water, 138; Northleach, 139; Cheltenham, 140; Cleeve Hill, 141; Winchcombe, 142; Tewkesbury, 143; Malvern, 144; Great Malvern, 145; Malvern Link, 146; Barnard's Green, 147; Storridge, 148; Welland, 149; Upton, 150; Powick, 151; Worcester, 152; Hanley Castle, 153; Upton, 154; Tewkesbury, 155; Ripple, 156; Tirley, 157; Ashleworth, 158; Hasfield, 159; Gloucester, 160; Cheltenham, 161; Bredon Hill, 162; Bredon, 163; Eckington, 164; Pershore, 165; Evesham, 166; Broadway, 167; Chipping Campden, 168; Blockley, 169; Moreton-in-the-Marsh, 170; Stow-on-the-Wold, 171; Bourton-on-the-Water, 172; Northleach, 173; Cheltenham, 174; Cleeve Hill, 175; Winchcombe, 176; Tewkesbury, 177; Malvern, 178; Great Malvern, 179; Malvern Link, 180; Barnard's Green, 181; Storridge, 182; Welland, 183; Upton, 184; Powick, 185; Worcester, 186; Hanley Castle, 187; Upton, 188; Tewkesbury, 189; Ripple, 190; Tirley, 191; Ashleworth, 192; Hasfield, 193; Gloucester, 194; Cheltenham, 195; Bredon Hill, 196; Bredon, 197; Eckington, 198; Pershore, 199; Evesham, 200; Broadway, 201; Chipping Campden, 202; Blockley, 203; Moreton-in-the-Marsh, 204; Stow-on-the-Wold, 205; Bourton-on-the-Water, 206; Northleach, 207; Cheltenham, 208; Cleeve Hill, 209; Winchcombe, 210; Tewkesbury, 211; Malvern, 212; Great Malvern, 213; Malvern Link, 214; Barnard's Green, 215; Storridge, 216; Welland, 217; Upton, 218; Powick, 219; Worcester, 220; Hanley Castle, 221; Upton, 222; Tewkesbury, 223; Ripple, 224; Tirley, 225; Ashleworth, 226; Hasfield, 227; Gloucester, 228; Cheltenham, 229; Bredon Hill, 230; Bredon, 231; Eckington, 232; Pershore, 233; Evesham, 234; Broadway, 235; Chipping Campden, 236; Blockley, 237; Moreton-in-the-Marsh, 238; Stow-on-the-Wold, 239; Bourton-on-the-Water, 240; Northleach, 241; Cheltenham, 242; Cleeve Hill, 243; Winchcombe, 244; Tewkesbury, 245; Malvern, 246; Great Malvern, 247; Malvern Link, 248; Barnard's Green, 249; Storridge, 250; Welland, 251; Upton, 252; Powick, 253; Worcester, 254; Hanley Castle, 255; Upton, 256; Tewkesbury, 257; Ripple, 258; Tirley, 259; Ashleworth, 260; Hasfield, 261; Gloucester, 262; Cheltenham, 263; Bredon Hill, 264; Bredon, 265; Eckington, 266; Pershore, 267; Evesham, 268; Broadway, 269; Chipping Campden, 270; Blockley, 271; Moreton-in-the-Marsh, 272; Stow-on-the-Wold, 273; Bourton-on-the-Water, 274; Northleach, 275; Cheltenham, 276; Cleeve Hill, 277; Winchcombe, 278; Tewkesbury, 279; Malvern, 280; Great Malvern, 281; Malvern Link, 282; Barnard's Green, 283; Storridge, 284; Welland, 285; Upton, 286; Powick, 287; Worcester, 288; Hanley Castle, 289; Upton, 290; Tewkesbury, 291; Ripple, 292; Tirley, 293; Ashleworth, 294; Hasfield, 295; Gloucester, 296; Cheltenham, 297; Bredon Hill, 298; Bredon, 299; Eckington, 300; Pershore, 301; Evesham, 302; Broadway, 303; Chipping Campden, 304; Blockley, 305; Moreton-in-the-Marsh, 306; Stow-on-the-Wold, 307; Bourton-on-the-Water, 308; Northleach, 309; Cheltenham, 310; Cleeve Hill, 311; Winchcombe, 312; Tewkesbury, 313; Malvern, 314; Great Malvern, 315; Malvern Link, 316; Barnard's Green, 317; Storridge, 318; Welland, 319; Upton, 320; Powick, 321; Worcester, 322; Hanley Castle, 323; Upton, 324; Tewkesbury, 325; Ripple, 326; Tirley, 327; Ashleworth, 328; Hasfield, 329; Gloucester, 330; Cheltenham, 331; Bredon Hill, 332; Bredon, 333; Eckington, 334; Pershore, 335; Evesham, 336; Broadway, 337; Chipping Campden, 338; Blockley, 339; Moreton-in-the-Marsh, 340; Stow-on-the-Wold, 341; Bourton-on-the-Water, 342; Northleach, 343; Cheltenham, 344; Cleeve Hill, 345; Winchcombe, 346; Tewkesbury, 347; Malvern, 348; Great Malvern, 349; Malvern Link, 350; Barnard's Green, 351; Storridge, 352; Welland, 353; Upton, 354; Powick, 355; Worcester, 356; Hanley Castle, 357; Upton, 358; Tewkesbury, 359; Ripple, 360; Tirley, 361; Ashleworth, 362; Hasfield, 363; Gloucester, 364; Cheltenham, 365; Bredon Hill, 366; Bredon, 367; Eckington, 368; Pershore, 369; Evesham, 370; Broadway, 371; Chipping Campden, 372; Blockley, 373; Moreton-in-the-Marsh, 374; Stow-on-the-Wold, 375; Bourton-on-the-Water, 376; Northleach, 377; Cheltenham, 378; Cleeve Hill, 379; Winchcombe, 380; Tewkesbury, 381; Malvern, 382; Great Malvern, 383; Malvern Link, 384; Barnard's Green, 385; Storridge, 386; Welland, 387; Upton, 388; Powick, 389; Worcester, 390; Hanley Castle, 391; Upton, 392; Tewkesbury, 393; Ripple, 394; Tirley, 395; Ashleworth, 396; Hasfield, 397; Gloucester, 398; Cheltenham, 399; Bredon Hill, 400; Bredon, 401; Eckington, 402; Pershore, 403; Evesham, 404; Broadway, 405; Chipping Campden, 406; Blockley, 407; Moreton-in-the-Marsh, 408; Stow-on-the-Wold, 409; Bourton-on-the-Water, 410; Northleach, 411; Cheltenham, 412; Cleeve Hill, 413; Winchcombe, 414; Tewkesbury, 415; Malvern, 416; Great Malvern, 417; Malvern Link, 418; Barnard's Green, 419; Storridge, 420; Welland, 421; Upton, 422; Powick, 423; Worcester, 424; Hanley Castle, 425; Upton, 426; Tewkesbury, 427; Ripple, 428; Tirley, 429; Ashleworth, 430; Hasfield, 431; Gloucester, 432; Cheltenham, 433; Bredon Hill, 434; Bredon, 435; Eckington, 436; Pershore, 437; Evesham, 438; Broadway, 439; Chipping Campden, 440; Blockley, 441; Moreton-in-the-Marsh, 442; Stow-on-the-Wold, 443; Bourton-on-the-Water, 444; Northleach, 445; Cheltenham, 446; Cleeve Hill, 447; Winchcombe, 448; Tewkesbury, 449; Malvern, 450; Great Malvern, 451; Malvern Link, 452; Barnard's Green, 453; Storridge, 454; Welland, 455; Upton, 456; Powick, 457; Worcester, 458; Hanley Castle, 459; Upton, 460; Tewkesbury, 461; Ripple, 462; Tirley, 463; Ashleworth, 464; Hasfield, 465; Gloucester, 466; Cheltenham, 467; Bredon Hill, 468; Bredon, 469; Eckington, 470; Pershore, 471; Evesham, 472; Broadway, 473; Chipping Campden, 474; Blockley, 475; Moreton-in-the-Marsh, 476; Stow-on-the-Wold, 477; Bourton-on-the-Water, 478; Northleach, 479; Cheltenham, 480; Cleeve Hill, 481; Winchcombe, 482; Tewkesbury, 483; Malvern, 484; Great Malvern, 485; Malvern Link, 486; Barnard's Green, 487; Storridge, 488; Welland, 489; Upton, 490; Powick, 491; Worcester, 492; Hanley Castle, 493; Upton, 494; Tewkesbury, 495; Ripple, 496; Tirley, 497; Ashleworth, 498; Hasfield, 499; Gloucester, 500; Cheltenham, 501; Bredon Hill, 502; Bredon, 503; Eckington, 504; Pershore, 505; Evesham, 506; Broadway, 507; Chipping Campden, 508; Blockley, 509; Moreton-in-the-Marsh, 510; Stow-on-the-Wold, 511; Bourton-on-the-Water, 512; Northleach, 513; Cheltenham, 514; Cleeve Hill, 515; Winchcombe, 516; Tewkesbury, 517; Malvern, 518; Great Malvern, 519; Malvern Link, 520; Barnard's Green, 521; Storridge, 522; Welland, 523; Upton, 524; Powick, 525; Worcester, 526; Hanley Castle, 527; Upton, 528; Tewkesbury, 529; Ripple, 530; Tirley, 531; Ashleworth, 532; Hasfield, 533; Gloucester, 534; Cheltenham, 535; Bredon Hill, 536; Bredon, 537; Eckington, 538; Pershore, 539; Evesham, 540; Broadway, 541; Chipping Campden, 542; Blockley, 543; Moreton-in-the-Marsh, 544; Stow-on-the-Wold, 545; Bourton-on-the-Water, 546; Northleach, 547; Cheltenham, 548; Cleeve Hill, 549; Winchcombe, 550; Tewkesbury, 551; Malvern, 552; Great Malvern, 553; Malvern Link, 554; Barnard's Green, 555; Storridge, 556; Welland, 557; Upton, 558; Powick, 559; Worcester, 560; Hanley Castle, 561; Upton, 562; Tewkesbury, 563; Ripple, 564; Tirley, 565; Ashleworth, 566; Hasfield, 567; Gloucester, 568; Cheltenham, 569; Bredon Hill, 570; Bredon, 571; Eckington, 572; Pershore, 573; Evesham, 574; Broadway, 575; Chipping Campden, 576; Blockley, 577; Moreton-in-the-Marsh, 578; Stow-on-the-Wold, 579; Bourton-on-the-Water, 580; Northleach, 581; Cheltenham, 582; Cleeve Hill, 583; Winchcombe, 584; Tewkesbury, 585; Malvern, 586; Great Malvern, 587; Malvern Link, 588; Barnard's Green, 589; Storridge, 590; Welland, 591; Upton, 592; Powick, 593; Worcester, 594; Hanley Castle, 595; Upton, 596; Tewkesbury, 597; Ripple, 598; Tirley, 599; Ashleworth, 600; Hasfield, 601; Gloucester, 602; Cheltenham, 603; Bredon Hill, 604; Bredon, 605; Eckington, 606; Pershore, 607; Evesham, 608; Broadway, 609; Chipping Campden, 610; Blockley, 611; Moreton-in-the-Marsh, 612; Stow-on-the-Wold, 613; Bourton-on-the-Water, 614; Northleach, 615; Cheltenham, 616; Cleeve Hill, 617; Winchcombe, 618; Tewkesbury, 619; Malvern, 620; Great Malvern, 621; Malvern Link, 622; Barnard's Green, 623; Storridge, 624; Welland, 625; Upton, 626; Powick, 627; Worcester, 628; Hanley Castle, 629; Upton, 630; Tewkesbury, 631; Ripple, 632; Tirley, 633; Ashleworth, 634; Hasfield, 635; Gloucester, 636; Cheltenham, 637; Bredon Hill, 638; Bredon, 639; Eckington, 640; Pershore, 641; Evesham, 642; Broadway, 643; Chipping Campden, 644; Blockley, 645; Moreton-in-the-Marsh, 646; Stow-on-the-Wold, 647; Bourton-on-the-Water, 648; Northleach, 649; Cheltenham, 650; Cleeve Hill, 651; Winchcombe, 652; Tewkesbury, 653; Malvern, 654; Great Malvern, 655; Malvern Link, 656; Barnard's Green, 657; Storridge, 658; Welland, 659; Upton, 660; Powick, 661; Worcester, 662; Hanley Castle, 663; Upton, 664; Tewkesbury, 665; Ripple, 666; Tirley, 667; Ashleworth, 668; Hasfield, 669; Gloucester, 670; Cheltenham, 671; Bredon Hill, 672; Bredon, 673; Eckington, 674; Pershore, 675; Evesham, 676; Broadway, 677; Chipping Campden, 678; Blockley, 679; Moreton-in-the-Marsh, 680; Stow-on-the-Wold, 681; Bourton-on-the-Water, 682; Northleach, 683; Cheltenham, 684; Cleeve Hill, 685; Winchcombe, 686; Tewkesbury, 687; Malvern, 688; Great Malvern, 689; Malvern Link, 690; Barnard's Green, 691; Storridge, 692; Welland, 693; Upton, 694; Powick, 695; Worcester, 696; Hanley Castle, 697; Upton, 698; Tewkesbury, 699; Ripple, 700; Tirley, 701; Ashleworth, 702; Hasfield, 703; Gloucester, 704; Cheltenham, 705; Bredon Hill, 706; Bredon, 707; Eckington, 708; Pershore, 709; Evesham, 710; Broadway, 711; Chipping Campden, 712; Blockley, 713; Moreton-in-the-Marsh, 714; Stow-on-the-Wold, 715; Bourton-on-the-Water, 716; Northleach, 717; Cheltenham, 718; Cleeve Hill, 719; Winchcombe, 720; Tewkesbury, 721; Malvern, 722; Great Malvern, 723; Malvern Link, 724; Barnard's Green, 725; Storridge, 726; Welland, 727; Upton, 728; Powick, 729; Worcester, 730; Hanley Castle, 731; Upton, 732; Tewkesbury, 733; Ripple, 734; Tirley, 735; Ashleworth, 736; Hasfield, 737; Gloucester, 738; Cheltenham, 739; Bredon Hill, 740; Bredon, 741; Eckington, 742; Pershore, 743; Evesham, 744; Broadway, 745; Chipping Campden, 746; Blockley, 747; Moreton-in-the-Marsh, 748; Stow-on-the-Wold, 749; Bourton-on-the-Water, 750; Northleach, 751; Cheltenham, 752; Cleeve Hill, 753; Winchcombe, 754; Tewkesbury, 755; Malvern, 756; Great Malvern, 757; Malvern Link, 758; Barnard's Green, 759; Storridge, 760; Welland, 761; Upton, 762; Powick, 763; Worcester, 764; Hanley Castle, 765; Upton, 766; Tewkesbury, 767; Ripple, 768; Tirley, 769; Ashleworth, 770; Hasfield, 771; Gloucester, 772; Cheltenham, 773; Bredon Hill, 774; Bredon, 775; Eckington, 776; Pershore, 777; Evesham, 778; Broadway, 779; Chipping Campden, 780; Blockley, 781; Moreton-in-the-Marsh, 782; Stow-on-the-Wold, 783; Bourton-on-the-Water, 784; Northleach, 785; Cheltenham, 786; Cleeve Hill, 787; Winchcombe, 788; Tewkesbury, 789; Malvern, 790; Great Malvern, 791; Malvern Link, 792; Barnard's Green, 793; Storridge, 794; Welland, 795; Upton, 796; Powick, 797; Worcester, 798; Hanley Castle, 799; Upton, 800; Tewkesbury, 801; Ripple, 802; Tirley, 803; Ashleworth, 804; Hasfield, 805; Gloucester, 806; Cheltenham, 807; Bredon Hill, 808; Bredon, 809; Eckington, 810; Pershore, 811; Evesham, 812; Broadway, 813; Chipping Campden, 814; Blockley, 815; Moreton-in-the-Marsh, 816; Stow-on-the-Wold, 817; Bourton-on-the-Water, 818; Northleach, 819; Cheltenham, 820; Cleeve Hill, 821; Winchcombe, 822; Tewkesbury, 823; Malvern, 824; Great Malvern, 825; Malvern Link, 826; Barnard's Green, 827; Storridge, 828; Welland, 829; Upton, 830; Powick, 831; Worcester, 832; Hanley Castle, 833; Upton, 834; Tewkesbury, 835; Ripple, 836; Tirley, 837; Ashleworth, 838; Hasfield, 839; Gloucester, 840; Cheltenham, 841; Bredon Hill, 842; Bredon, 843; Eckington, 844; Pershore, 845; Evesham, 846; Broadway, 847; Chipping Campden, 848; Blockley, 849; Moreton-in-the-Marsh, 850; Stow-on-the-Wold, 851; Bourton-on-the-Water, 852; Northleach, 853; Cheltenham, 854; Cleeve Hill, 855; Winchcombe, 856; Tewkesbury, 857; Malvern, 858; Great Malvern, 859; Malvern Link, 860; Barnard's Green, 861; Storridge, 862; Welland, 863; Upton, 864; Powick, 865; Worcester, 866; Hanley Castle, 867; Upton, 868; Tewkesbury, 869; Ripple, 870; Tirley, 871; Ashleworth, 872; Hasfield, 873; Gloucester, 874; Cheltenham, 875; Bredon Hill, 876; Bredon, 877; Eckington, 878; Pershore, 879; Evesham, 880; Broadway, 881; Chipping Campden, 882; Blockley, 883; Moreton-in-the-Marsh, 884; Stow-on-the-Wold, 885; Bourton-on-the-Water, 886; Northleach, 887; Cheltenham, 888; Cleeve Hill, 889; Winchcombe, 890; Tewkesbury, 891; Malvern, 892; Great Malvern, 893; Malvern Link, 894; Barnard's Green, 895; Storridge, 896; Welland, 897; Upton, 898; Powick, 899; Worcester, 900; Hanley Castle, 901; Upton, 902; Tewkesbury, 903; Ripple, 904; Tirley, 905; Ashleworth, 906; Hasfield, 907; Gloucester, 908; Cheltenham, 909; Bredon Hill, 910; Bredon, 911; Eckington, 912; Pershore, 913; Evesham, 914; Broadway, 915; Chipping Campden, 916; Blockley, 917; Moreton-in-the-Marsh, 918; Stow-on-the-Wold, 919; Bourton-on-the-Water, 920; Northleach, 921; Cheltenham, 922; Cleeve Hill, 923; Winchcombe, 924; Tewkesbury, 925; Malvern, 926; Great Malvern, 927; Malvern Link, 928; Barnard's Green, 929; Storridge, 930; Welland, 931; Upton, 932; Powick, 933; Worcester, 934; Hanley Castle, 935; Upton, 936; Tewkesbury, 937; Ripple, 938; Tirley, 939; Ashleworth, 940; Hasfield, 941; Gloucester, 942; Cheltenham, 943; Bredon Hill, 944; Bredon, 945; Eckington, 946; Pershore, 947; Evesham, 948; Broadway, 949; Chipping Campden, 950; Blockley, 951; Moreton-in-the-Marsh, 952; Stow-on-the-Wold, 953; Bourton-on-the-Water, 954; Northleach, 955; Cheltenham, 956; Cleeve Hill, 957; Winchcombe, 958; Tewkesbury, 959; Malvern, 960; Great Malvern, 961; Malvern Link, 962; Barnard's Green, 963; Storridge, 964; Welland, 965; Upton, 966; Powick, 967; Worcester, 968; Hanley Castle, 969; Upton, 970; Tewkesbury, 971; Ripple, 972; Tirley, 973; Ashleworth, 974; Hasfield, 975; Gloucester, 976; Cheltenham, 977; Bredon Hill, 978; Bredon, 979; Eckington, 980; Pershore, 981; Evesham, 982; Broadway, 983; Chipping Campden, 984; Blockley, 985; Moreton-in-the-Marsh, 986; Stow-on-the-Wold, 987; Bourton-on-the-Water, 988; Northleach, 989; Cheltenham, 990; Cleeve Hill, 991; Winchcombe, 992; Tewkesbury, 993; Malvern, 994; Great Malvern, 995; Malvern Link, 996; Barnard's Green, 997; Storridge, 998; Welland, 999; Upton, 1000; Powick, 1001; Worcester, 1002; Hanley Castle, 1003; Upton, 1004; Tewkesbury, 1005; Ripple, 1006; Tirley, 1007; Ashleworth, 1008; Hasfield, 1009; Gloucester, 1010; Cheltenham, 1011; Bredon Hill, 1012; Bredon, 1013; Eckington, 1014; Pershore, 1015; Evesham, 1016; Broadway, 1017; Chipping Campden, 1018; Blockley, 1019; Moreton-in-the-Marsh, 1020; Stow-on-the-Wold, 1021; Bourton-on-the-Water, 1022; Northleach, 1023; Cheltenham, 1024; Cleeve Hill, 1025; Winchcombe, 1026; Tewkesbury, 1027; Malvern, 1028; Great Malvern, 1029; Malvern Link, 1030; Barnard's Green, 1031; Storridge, 1032; Welland, 1033; Upton, 1034; Powick, 1035; Worcester, 1036; Hanley Castle, 1037; Upton, 1038; Tewkesbury, 1039; Ripple, 1040; Tirley, 1041; Ashleworth, 1042; Hasfield, 1043; Gloucester, 1044; Cheltenham, 1045; Bredon Hill, 1046; Bredon, 1047; Eckington, 1048; Pershore, 1049; Evesham, 1050; Broadway, 1051; Chipping Campden, 1052; Blockley, 1053; Moreton-in-the-Marsh, 1054; Stow-on-the-Wold, 1055; Bourton-on-the-Water, 1056; Northleach, 1057; Cheltenham, 1058; Cleeve Hill, 1059; Winchcombe, 1060; Tewkesbury, 1061; Malvern, 1062; Great Malvern, 1063; Malvern Link, 1064; Barnard's Green, 1065; Storridge, 1066; Welland, 1067; Upton, 1068; Powick, 1069; Worcester, 1070; Hanley Castle, 1071; Upton, 1072; Tewkesbury, 1073; Ripple, 1074; Tirley, 1075; Ashleworth, 1076; Hasfield, 1077; Gloucester, 1078; Cheltenham, 1079; Bredon Hill, 1080; Bredon, 1081; Eckington, 1082; Pershore, 1083; Evesham, 1084; Broadway, 1085; Chipping Campden, 1086; Blockley, 1087; Moreton-in-the-Marsh, 1088; Stow-on-the-Wold, 1089; Bourton-on-the-Water, 1090; Northleach, 1091; Cheltenham, 1092; Cleeve Hill, 1093; Winchcombe, 1094; Tewkesbury, 1095; Malvern, 1096; Great Malvern, 1097; Malvern Link, 1098; Barnard's Green, 1099; Storridge, 1100; Welland, 1101; Upton, 1102; Powick, 1103; Worcester, 1104; Hanley Castle, 1105; Upton, 1106; Tewkesbury, 1107; Ripple, 1108; Tirley, 1109; Ashleworth, 1110; Hasfield, 1111; Gloucester, 1112; Cheltenham, 1113; Bredon Hill, 1114; Bredon, 1115; Eckington, 1116; Pershore, 1117; Evesham, 1118; Broadway, 1119; Chipping Campden, 1120; Blockley, 1121; Moreton-in-the-Marsh, 1122; Stow-on-the-Wold, 1123; Bourton-on-the-Water, 1124; Northleach, 1125; Cheltenham, 1126; Cleeve Hill, 1127; Winchcombe, 1128; Tewkesbury, 1129; Malvern, 1130; Great Malvern, 1131; Malvern Link, 1132; Barnard's Green, 1133; Storridge, 1134; Welland, 1135; Upton, 1136; Powick, 1137; Worcester, 1138; Hanley Castle, 1139; Upton, 1140; Tewkesbury, 1141; Ripple, 1142; Tirley, 1143; Ashleworth, 1144; Hasfield, 1145; Gloucester, 1146; Cheltenham, 1147; Bredon Hill, 1148; Bredon, 1149; Eckington, 1150; Pershore, 1151; Evesham, 1152; Broadway, 1153; Chipping Campden, 1154; Blockley, 1155; Moreton-in-the-Marsh, 1156; Stow-on-the-Wold, 1157; Bourton-on-the-Water, 1158; Northleach, 1159; Cheltenham, 1160; Cleeve Hill, 1161; Winchcombe, 1162; Tewkesbury, 1163; Malvern, 1164; Great Malvern, 1165; Malvern Link, 1166; Barnard's Green, 1167; Storridge, 1168; Welland, 1169; Upton, 1170; Powick, 1171; Worcester, 1172; Hanley Castle, 1173; Upton, 1174; Tewkesbury, 1175; Ripple, 1176; Tirley, 1177; Ashleworth, 1178; Hasfield, 1179; Gloucester, 1180; Cheltenham, 1181; Bredon Hill, 1182; Bredon, 1183; Eckington, 1184; Pershore, 1185; Evesham, 1186; Broadway, 1187; Chipping Campden, 1188; Blockley, 1189; Moreton-in-the-Marsh, 1190; Stow-on-the-Wold, 1191; Bourton-on-the-Water, 1192; Northleach, 1193; Cheltenham, 1194; Cleeve Hill, 1195; Winchcombe, 1196; Tewkesbury, 1197; Malvern, 1198; Great Malvern, 1199; Malvern Link, 1200; Barnard's Green, 1201; Storridge, 1202; Welland, 1203; Upton, 1204; Powick, 1205; Worcester, 1206; Hanley Castle, 1207; Upton, 1208; Tewkesbury, 1209; Ripple, 1210; Tirley, 1211; Ashleworth, 1212; Hasfield, 1213; Gloucester, 1214; Cheltenham, 1215; Bredon Hill, 1216; Bredon, 1217; Eckington, 1218; Pershore, 1219; Evesham, 1220; Broadway, 1221; Chipping Campden, 1222; Blockley, 1223; Moreton-in-the-Marsh, 1224; Stow-on-the-Wold, 1225; Bourton-on-the-Water, 1226; Northleach, 1227; Cheltenham, 1228; Cleeve Hill, 1229; Winchcombe, 1230; Tewkesbury, 1231; Malvern, 1232; Great Malvern, 1233; Malvern Link, 1234; Barnard's Green, 1235; Storridge, 1236; Welland, 1237; Upton, 1238; Powick, 1239; Worcester, 1240; Hanley Castle, 1241; Upton, 1242; Tewkesbury, 1243; Ripple, 1244; Tirley, 1245; Ashleworth, 1246; Hasfield, 1247; Gloucester, 1248; Cheltenham, 1249; Bredon Hill, 1250; Bredon, 1251; Eckington, 1252; Pershore, 1253; Evesham, 1254; Broadway, 1255; Chipping Campden, 1256; Blockley, 1257; Moreton-in-the-Marsh, 1258; Stow-on-the-Wold, 1259; Bourton-on-the-Water, 1260; Northleach, 1261; Cheltenham, 1262; Cleeve Hill, 1263; Winchcombe, 1264; Tewkesbury, 1265; Malvern, 1266; Great Malvern, 1267; Malvern Link, 1268; Barnard's Green, 1269; Storridge, 1270; Welland, 1271; Upton, 1272; Powick, 1273; Worcester, 1274; Hanley Castle, 1275; Upton, 1276; Tewkesbury, 1277; Ripple, 1278; Tirley, 1279; Ashleworth, 1280; Hasfield, 1281; Gloucester, 1282; Cheltenham, 1283; Bredon Hill, 1284; Bredon, 1285; Eckington, 1286; Pershore, 1287; Evesham, 1288; Broadway, 1289; Chipping Campden, 1290; Blockley, 1291; Moreton-in-the-Marsh, 1292; Stow-on-the-Wold, 1293; Bourton-on-the-Water, 1294; Northleach, 1295; Cheltenham, 1296; Cleeve Hill, 1297; Winchcombe, 1298; Tewkesbury, 1299; Malvern, 1300; Great Malvern, 1301; Malvern Link, 1302; Barnard's Green, 1303; Storridge, 1304; Welland, 1305; Upton, 1306; Powick, 1307; Worcester, 1308; Hanley Castle, 1309; Upton, 1310; Tewkesbury, 1311; Ripple, 1312; Tirley, 1313; Ashleworth, 1314; Hasfield, 1315; Gloucester, 1316; Cheltenham, 1317; Bredon Hill, 1318; Bredon, 1319; Eckington, 1320; Pershore, 1321; Evesham, 1322; Broadway, 1323; Chipping Campden, 1324; Blockley, 1325; Moreton-in-the-Marsh, 1326; Stow-on-the-Wold, 1327; Bourton-on-the-Water, 1328; Northleach, 1329; Cheltenham, 1330; Cleeve Hill, 1331; Winchcombe, 1332; Tewkesbury, 1333; Malvern, 1334; Great Malvern, 1335; Malvern Link, 1336; Barnard's Green, 1337; Storridge, 1338; Welland, 1339; Upton, 1340; Powick, 1341; Worcester, 1342; Hanley Castle, 1343; Upton, 1344; Tewkesbury, 1345; Ripple, 1346; Tirley, 1347; Ashleworth, 1348; Hasfield, 1349; Gloucester, 1350; Cheltenham, 1351; Bredon Hill, 1352; Bredon, 1353; Eckington, 1354; Pershore, 1355; Evesham, 1356; Broadway, 1357; Chipping Campden, 1358; Blockley, 1359; Moreton-in-the-Marsh, 1360; Stow-on-the-Wold, 1361; Bourton-on-the-Water, 1362; Northleach, 1363; Cheltenham, 1364; Cleeve Hill, 1365; Winchcombe, 1366; Tewkesbury, 1367; Malvern, 1368; Great Malvern, 1369; Malvern Link, 1370; Barnard's Green, 1371; Storridge, 1372; Welland, 1373; Upton, 1374; Powick, 1375; Worcester, 1376; Hanley Castle, 1377; Upton, 1378; Tewkesbury, 1379; Ripple, 1380; Tirley, 1381; Ashleworth, 1382; Hasfield, 1383; Gloucester, 1384; Cheltenham, 1385; Bredon Hill, 1386; Bredon, 1387; Eckington, 1388; Pershore, 1389; Evesham, 1390; Broadway, 1391; Chipping Campden, 1392; Blockley, 1393; Moreton-in-the-Marsh, 1394; Stow-on-the-Wold, 1395; Bourton-on-the-Water, 1396; Northleach, 1397; Cheltenham, 1398; Cleeve Hill, 1399; Winchcombe, 1400; Tewkesbury, 1401; Malvern, 1402; Great Malvern, 1403; Malvern Link, 1404; Barnard's Green, 1405; Storridge, 1406; Welland, 1407; Upton, 1408; Powick, 1409; Worcester, 1410; Hanley Castle, 1411; Upton, 1412; Tewkesbury, 1413; Ripple, 1414; Tirley, 1415; Ashleworth, 1416; Hasfield, 1417; Gloucester, 1418; Cheltenham, 1419; Bredon Hill, 1420; Bredon, 1421; Eckington, 1422; Pershore, 1423; Evesham, 1424; Broadway, 1425; Chipping Campden, 1426; Blockley, 1427; Moreton-in-the-Marsh, 1428; Stow-on-the-Wold, 1429; Bourton-on-the-Water, 1430; Northleach, 1431; Cheltenham, 1432; Cleeve Hill, 1433; Winchcombe, 1434; Tewkesbury, 1435; Malvern, 1436; Great Malvern, 1437; Malvern Link, 1438; Barnard's Green, 1439; Storridge, 1440; Welland, 1441; Upton, 1442; Powick, 1443; Worcester, 1444; Hanley Castle, 1445; Upton, 1446; Tewkesbury, 1447; Ripple, 1448; Tirley, 1449; Ashleworth, 1450; Hasfield, 1451; Gloucester, 1452; Cheltenham, 1453; Bredon Hill, 1454; Bredon, 1455; Eckington, 1456; Pershore, 1457; Evesham, 1458; Broadway, 1459; Chipping Campden, 1460; Blockley, 1461; Moreton-in-the-Marsh, 1462; Stow-on-the-Wold, 1463; Bourton-on-the-Water, 1464; Northleach, 1465; Cheltenham, 1466; Cleeve Hill, 1467; Winchcombe, 1468; Tewkesbury, 1469; Malvern, 1470; Great Malvern, 1471; Malvern Link, 1472; Barnard's Green, 1473; Storridge, 1474; Welland, 1475; Upton, 1476; Powick, 1477; Worcester, 1478; Hanley Castle, 1479; Upton, 1480; Tewkesbury, 1481; Ripple, 1482; Tirley, 1483; Ashleworth, 1484; Hasfield, 1485; Gloucester, 1486; Cheltenham, 1487; Bredon Hill, 1488; Bredon, 1489; Eckington, 1490; Pershore, 1491; Evesham, 1492; Broadway, 1493; Chipping Campden, 1494; Blockley, 1495; Moreton-in-the-Marsh, 1496; Stow-on-the-Wold, 1497; Bourton-on-the-Water, 1498; Northleach, 1499; Cheltenham, 1500; Cleeve Hill, 1501; Winchcombe, 1502; Tewkesbury, 1503; Malvern, 1504; Great Malvern, 1505; Malvern Link, 1506; Barnard's Green, 1507; Storridge, 1508; Welland, 1509; Upton, 1510; Powick, 1511; Worcester, 1512; Hanley Castle, 1513; Upton, 1514; Tewkesbury, 1515; Ripple, 1516; Tirley, 1517; Ashleworth, 1518; Hasfield, 1519; Gloucester, 1520; Cheltenham, 1521; Bredon Hill, 1522; Bredon, 1523; Eckington, 1524; Pershore, 1525; Evesham, 1526; Broadway, 1527; Chipping Campden, 1528; Blockley, 1529; Moreton-in-the-Marsh, 1530; Stow-on-the-Wold, 1531; Bourton-on-the-Water, 1532; Northleach, 1533; Cheltenham, 1534; Cleeve Hill, 1535; Winchcombe, 1536; Tewkesbury, 1537; Malvern, 1538; Great Malvern, 1539; Malvern Link, 1540; Barnard's Green, 1541; Storridge, 1542; Welland, 1543; Upton, 1544; Powick, 1545; Worcester, 1546; Hanley Castle, 1547; Upton, 1548; Tewkesbury, 1549; Ripple, 1550; Tirley, 1551; Ashleworth, 1552; Hasfield,

Narberth, strata of, 218; localities near, 322
Nautilus undosus, a rare shell in Llandilo flags, 352
Nemertina, 227
Nemertites, 230
Nereidina, 227
Nereites, 228
Nerita, 258
Newent sandstone and conglomerate, 114; new red marl, 115; Keüper; new red marls, 123
New red? of Malvern, general characters of composition, 110; vertical section of the whole, 111; description of Haffield conglomerate, &c., *ib.*
Noeth Grug, localities near, 326.
North Hills, 34; view of, 35; beautiful and various syenites in it; epidote veins; large crystals of mica; brecciated traps; red sandstone in contact, 36
Notices already published on the Malvern Hills and parts adjacent, 2
Nucula, 268. 366
Nuttainia, 339

Obelisk in Eastnor Park, traps near it, 56; strata here seen, 57
Odontopleuræ, 348
Ogygia, 239
Ogygiæ, 339
Oldham, Prof., referred to, 386
Old red of Malvern; classification of its beds; its characters in the Malvern district; range and extent, 102, 103
Olenus, 239, 346
Onchus, Ludlow rocks, 226
Orbicula, 276, 371
Organic remains, outlines of, in black shale, 55; lists of, 61, 65, 69, 73, 88, 100, 201, 204; discussions regarding the philosophy of, 74, 208–225; lists and tables of the several classes, 226–314; tables, calculations, and references, 315–321
Origin of the Malvern rocks; conglomerates, sandstones, clay, limestones, 39
Origin of the stratified masses of Malvern, 124
Ormoceras—note, 354
Orthis, 286, 372; O. calligramma, including numerous species, 374
Orthoceras, 247, 353; structure of siphuncle
Orthonota, 265, 359; includes the Silurian Cypricardiæ; allied to the Mytilacidæ and Arcidæ, 264.
Orthonota amygdalina, very widely distributed, 272
Ostracoda, 232

Palæadæ, *see* Trilobites
Palechinus, 302, 384
Palæontological Appendix, 331
Palæozoic districts of the memoir defined; their eastern boundary, 5; their systematic elevation, flexure, fracture, 6, 7; connexion of these with the movements in South Wales and Ireland, 8
Palæozoic life, system of, 211
Palæozoic strata of Malvern, 51; of Abberley, 145; of Woolhope, 164; of May Hill, 181; of Tortworth, 190; of Usk, 198
Paradoxides, 236, 341, 347
Patella, 258
Peach. C., referred to, 199
Pectinibranchiata, 256
Peltura, 347
Pentamerus, 291
Pentamerus Knightii, in Abberley district, 163: in Woolhope district, 178
Petraia, 309
Phacops, 239–335
Phillips, Professor J., his papers on the Malvern Hills, 4; descriptions of new species, 331
Phillips, Wm., on the geology of the Malvern Hills, 2
Philosophy of organic remains, 208
Pholadomyidæ, ? 265
Phragmoceras, 250
Physical geography of Malvern Hills, 9
Pileopsis, 258
Placoid fishes, 226; frequent in Silurian rocks, 226
Plants, list of, 312
Plants, remains of, at Malvern, 312
Plants, leaf-like markings at Woolhope, 312
Platynotus, 339
Pleurorhynchus, 265, 359
Pleurotomaria, 260, 357
Polyphysa, 386
Polypiaria, lists of, 303; tables and descriptions, 313
Porites, 310
Portlock, Major, referred to, 227, 230
Position of the strata in the Malvern district, 134; various characters of dip; three lines of violent inclination to the west; reversal of beds; geological period of the flexures; rarity of faults; occurrence of twists; absence of cleavage; mechanical illustrations of the movements of strata; false apparent dips; explanations of overthrown beds; faults and flexures contrasted; horizontal thrusts may be due to vertical movements, 134–144
Preliminary notice; date of the survey; dates of publication, by various authors, 1–4
Proetus, 239, 337
Pterinea, 368
Pteropoda, 255. 355
Ptilodictya, 310
Pterygotus, 234
Ptychoparia, 341
Pyrton Passage, 190, 192, 226

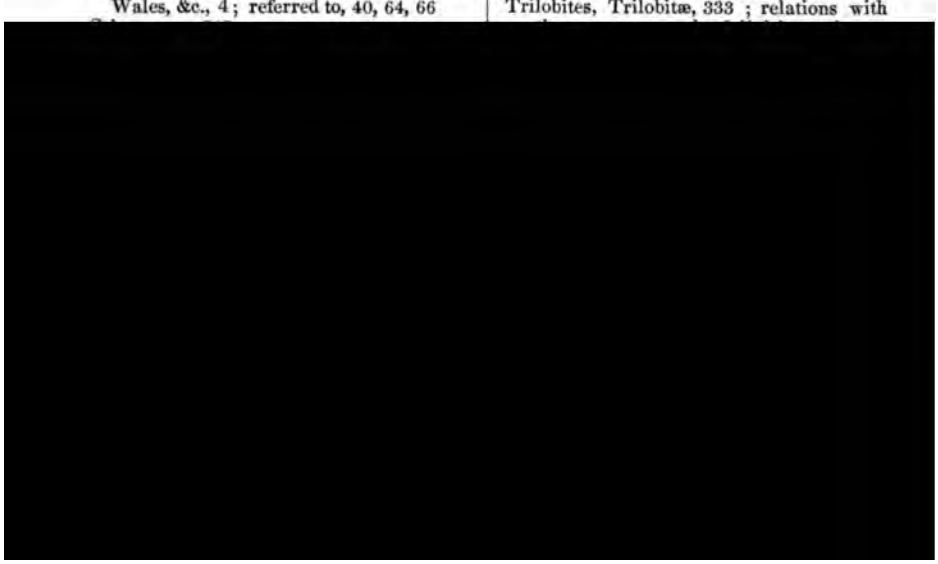
Quartz masses in the syenites, 32
Quenstedt, referred to, 235

Rafinesque; author of genus Strophomena, 377
Ragged-stone Hill, 26, *et seq.*; its double summit; remarkable composition and

structure of its rocks; traces of metamorphism, and diagram, 27
Ramsay, Prof., his surveys near Tortworth, 4
Remains of life in the Lower Palæozoic strata, 208
Retepora, 311
Reversal of strata (Malvern), 70, 71, 138, 139; (Abberley), 149–154
Rhodocrinites, 301
Richardson, Sir John, referred to, 214
Ridgeway, 79
Rilbury Camp, line of elevation, 79
Robeston Wathen, strata at, 219
Rough-hill, Caradoc beds, 62
Rowick, traps at, 56

Salter, J. W., his examination of the crustacea; of the region of Builth; other assistance to the author, 225, *et passim*
—— on Cornulites, &c., 227; on Silurian Cypricardiæ, 264; descriptions of species, 331
Sanders, W., his surveys near Tortworth, 4
Sanguinolaria, 360
Sections (Malvern), series of, 7; gravel-pit, 15; chlorite vein, 33; Cowley Park, 37; Abberley syenite, 38; transverse, of Malvern, 50; vertical, of Malvern, 51; Hollybush, 52; Caradoc conglomerates, 58; Caradoc in trap, 64; shelly conglomerate, 67; Caradoc, &c., 73, 76; Wenlock, &c., 82, 85–87; Aymestry Rock, &c., 92, 94; Upper Ludlow, &c., 97, 98, 99; old red, 102; carboniferous series, 105–109; mesozoic strata, 111; Keüper, 116, 118, 119, 120, 122; old red, 131; apparent reversals, 139; (Abberley), Wenlock limestone, 147; Upper Ludlow, &c., 149, 150–153; beds in contact with trap, 157; coal series, 158–160; (Woolhope), 167, 172, 173, 178; (May Hill), 182; Woolhope beds, 184; Wenlock, 186; Ludlow, 187; (Tortworth), 192, 193, 195, 198 (Usk), 200–204
Sedgwick, Professor A., his papers on North Wales, &c., 4; referred to, 40, 64, 66
Spirorbis, 228
Spongarium, 312
Spongarium Edwardsii, a plant, 386
Springs in Malvern Hills, 16
St. Clair's, strata of, 219; localities near, 323
Storridge, Caradoc beds at, 63; Woolhope limestone, 75, 77
Strata, particular sections of, 27, 37, 38, 50, 51, 52, 58, 64, 67, 73, 76, 82, 85–87, 92–94, 97–99, 102, 105–109, 111, 116, 118–122, 131, 139, 147, 149, 153, 157, 158–160, 167, 172–173, 178, 182, 183, 186, 187, 188, 192. 193, 195, 198, 200, 201–204
Strickland, H. E., referred to, 176
Stromatopora, 311
Strombodes, 311
Strophomena, 377
Stumps Wood, 63, 72
Subsidences of areas, 140, 222
Swinyard Hill; its syenitic and granitic compounds, epidote veins, &c.; superposition of Silurian strata, 29
Syenitic group, classified and described, 40, 41
Syringopora, 311
System of Lower Palæozoic life, 211

Tables of organic remains, including geographical and geological distributions, 231–319
Tentaculites, 229; an annelide, 227
Tentaculites annulatus, wide distribution of, 232
Terebra, 357
Theca, 255, 355
Tortworth district, 190; Pyrton fish beds, 192; traps, 194; their contemporaneous effusion, 195; Caradoc beds, 196; magnesian conglomerates, 198, 216; localities in, 328
Trachyderma, new genus, 230, 331
Trap, bedded structures in, 25; altered rocks near, 27
Trilobites, oldest forms, 242; fragmentary state in the Malvern region, 245
Trilobites, Trilobitæ, 333; relations with



l, Brock Hill, Hall Court, Hale's-
n, 94–99; fossils, 100–101; (Ab-
148; reversed beds, 149, 153;
e, 174; May Hill, 187; Usk,

rians, their lower boundary at
discussed, 73–75
ct; its geographical relations;
r of the elevation; thickness; its
series. in what peculiar; the pe-
investigated; sections and lists
s; bands of fossils; inferences,
; localities in, 327

ora, 312
Malvern hills, 9, 21; Hereford
30; from Gold Pits, 31; from
er Beacon, 35; from May Hill,

ell, reversal of beds here, 70, 72,

'., on the geology of part of Glou-
re, 4, 194
Malvern, 16
limestone (Malvern); in two or
nds; thickness; composition;
nary; stained red; pink spar
s; water-lines in joints; anti-
range; dips; local peculiarities;
ons; repeated outcrops; faults;
78–89; (Abberley), 147; (Wool-
70; (May Hill), 185; analysis,

shale (Malvern), 76; its small
oda; concretionary structure;
nd extent; affinity to Woolhope
e; (Abberley), 147; (Woolhope),
May Hill), 184

Whiteleaved Oak, black shale there, 54
Williams, D., his surveys near Tortworth, 4
Wind's Point, remarkable structures in great quarry near, 31
Winning's Farm, 77, 80
Wonder, 176, 177
Woolhope district, 164; elevations in, and round it, 165; general descriptions; series of strata, 167; Caradoc, 167; Woolhope, 168; Wenlock shale, 170; Wenlock limestone, 170; Lower Ludlow, 172; Aymestry rock, 172; Upper Ludlow, 174; the Wonder, 177; Shacknall Hill, 179; Bartestree Dyke, 180; general inference, 180; localities in, 328
Woolhope limestone (Malvern), 69; discussions on its fossils, 73–75; Abberley, 147; Woolhope, 168; May Hill, 185; localities in, 327
Wooltack Bay, 218, 219
Worcestershire Beacon, 33; granite and syenite of; veins of mica; large crystals of felspar; ramifications and segregations of minerals; brecciated traps; Caradoc beds, and shelly conglomerate on its western side; white and red sandstones on its eastern side, 33, 34; granite of, 42; fine sections of strata west of it, 65; diagram, 73; conglomerate discovered here, 66–68
Wright, J. R., on the geology of the vicinity of Ludlow, 3
Wych, 33, &c.; chlorite vein through the syenite; diagram, 33; Caradoc sandstones inclosed in syenite, 33; bedded rocks, 47; diagram, 64; fossils, 64

Yates, J., on the border country of Wales, 3

ERRATA AND ADDENDA.

Page 148, line 30, *for* Pl. 3 *read* Pl. 2.
192, line 7, *for* Pl. 4 *read* Pl. 3.
203, line 13 from bottom, *for* '*rotunda*' *read* '*rotundata*.'
204, line 14 from bottom, *for* '*lunaris*' *read* '*lunata*.'
205, line 4 from bottom, *for* Meristomyæ *read* Orthonotæ.
206, line 13 and note, *for* '*Meristomya*' *read* '*Orthonota*.'
215, line 13 from bottom, *for* 'the distribution' *read* 'both kinds of distribution.'
— line 12 from bottom, *dele* 'equally.'
226, line 18, *after* N.S. DECORUS *add* Pal. Appendix, Pl. XXX., f. 5.
238, line 8, *for* Cilgaun *read* Cilwaun.
255, line 16 from bottom, *after* REF. *add* '*C. quadrisulcata*.'
341, line 5 from bottom, *after* 'English specimens' *add* 'with those from Bohemia; the examples from Llandilo.'
345, to line 4 *add*, Tail [a portion at Shole's Hook, evidently belonging to the genus, of which this is the only species present there] semi-oval, axis broad, of three rings, besides a rudimentary one on the terminal joint; no central mucro, or terminal pair of spines; second pair strong, directly vertical, not first curved outwards, the end a little bent in and upwards; distance from the outer edge of this spine to the side of the axis, about half that of the breadth of the axis. [In all these particulars it differs from the tail of *Cheirurus speciosus*.]
364, line 5 from bottom, *for* 'without' *read* 'not including.'
365, line 14 from bottom, *for* 17 *read* 11.

EXPLANATION OF THE PLATES OF ORGANIC REMAINS.

Plate IV.

Fig. 1, 2. TRACHYDERMA CORIACEA, *Phillips*, 331.
2 *a*. Surface of ditto magnified.
3, 4. TRACHYDERMA SQUAMOSA, *Phillips*, 332.

Plate V.

Fig. 1. PHACOPS STOKESII, *Milne Edwards*, 335.
1 *a*. ——— same specimen, magnified.
2. PHACOPS DOWNINGIÆ, *Murchison*, 336.
3, 4. Tails of ditto, from same locality, 3 *a* magnified.
5. DALMANNIA AFFINIS, *Salter*, 337.
6. ILLÆNUS ROSENBERGII, *Eichwald*, 338.
7. ——— head of same species.
8. ——— body, same locality.

Plate VI.

Fig. 1. PROETUS LATIFRONS, *M'Coy*, 337.
1 *a*, *b*, *c*. ——— same specimen magnified.
2. PROETUS, sp. —— Rock farm, May Hill.
2 *a*, *b*. ——— same magnified.
3. ——— same species, Rock farm.
4. PROETUS, sp., probably the same, 4 *a* magnified.

Figs. 2 to 4 have not been yet named, because time will not allow of full comparison with the numerous Bohemian species. Fig. 2, however, occurs at Dudley, and Mr. Fletcher of that place has beautiful specimens in his cabinet.

Plate VII.

Fig. 1. SPHÆREXOCHUS JUVENIS, *Salter*, 344, 1 *a*.
——— same viewed sideways.
2, 3. ——— younger specimens, same locality.
4. CHEIRURUS SPECIOSUS, *Dalman*, 345. The basal glabella lobes differ in shape from those of *C. insignis*.
5. ——— same locality.
6. ——— the fine specimen, of which this is a fragment, was 5¾ inches broad, and therefore probably 7 inches or more long. The oblique and vertical strong furrows mark the places of thick ridges on the under side of the pleuræ.
7. Tail of ditto, from a different locality.

Plate VIII.

Fig. 1. ILLÆNUS BOWMANNI, *Salter*, 339; 1 *a*, side view ditto.
2. ——— specimen figured by Portlock, Geol. Report, Tyrone, &c. Pl. X. fig. 4.
3. ——— young specimen, figured by Portlock, fig. 5.

Fig. 4. LICHAS LAXATUS, *M'Coy*, 340; 4 *a*, surface magnified.
5. ——— tail.
6. ———, large specimen in Rev. T. T. Lewis's collection.
7. LICHAS VERRUCOSUS, *Eichwald*, 340, 7 *a*.
8. LICHAS, sp. undescribed, from Ledbury, 340; 8 *a*, surface magnified.
9. CYBELE SEXCOSTATA, *Salter*, 343.
——— 9 *a*, cheek-piece, with elongate footstalk of the ey
——— 9 *b*, surface of glabella magnified.
10. ——— tail.
11. AGNOSTUS TRINODUS, *Salter*, 351; 11 *a*, magnified.
12. AGNOSTUS TRINODUS, var. β CONVEXUS, head; 351, 12 *a*, magnified.
13. ——— tail; 13 *a*, magnified.
14. BEYRICHIA TUBERCULATA, *Klöden*, 352; 14 *a*, magnified.
15. ——— internal cast; 15 *a*, magnified.
16. BEYRICHIA COMPLICATA, *Salter*, internal cast, 352; 16*a*, magnified.
17, 18. BEYRICHIA GIBBA, *Salter*, internal cast; 352*a*, magnified.

Plate IX.

Fig. 1. TRINUCLEUS ORNATUS, *Sternberg*, 349.
2. ——— fringe of the head magnified; the fringe is hollow flat upper crust, the perforations continued as shelly tubes throug inferior surface; *b*, *c*, impression of the under side, the stone rising tubes; the surface divided by an angular ridge.
3. TRINUCLEUS ORNATUS, var. δ. FAVUS, 350.
4. ACIDASPIS BISPINOSUS, *M'Coy*, 349; 4 *a*, side view of ditto; 4 *b*, surface fied. The specimens from Dudley in Mr. Gray's collection.
5. ——— ditto, from Wexford; *a*, body-ring magnified magnified.
6. A. BRIGHTII, *Murchison*, 348. In Mr. Gray's collection.
7. ——— tail.
8. ——— internal cast of head.
9. ——— cast of interior of the tail.

Plate X.

Fig. 1. AMPYX PARVULUS, *Forbes*, 350; 1 *a* magnified.
2. ——— head natural size; 2 *a* magnified.

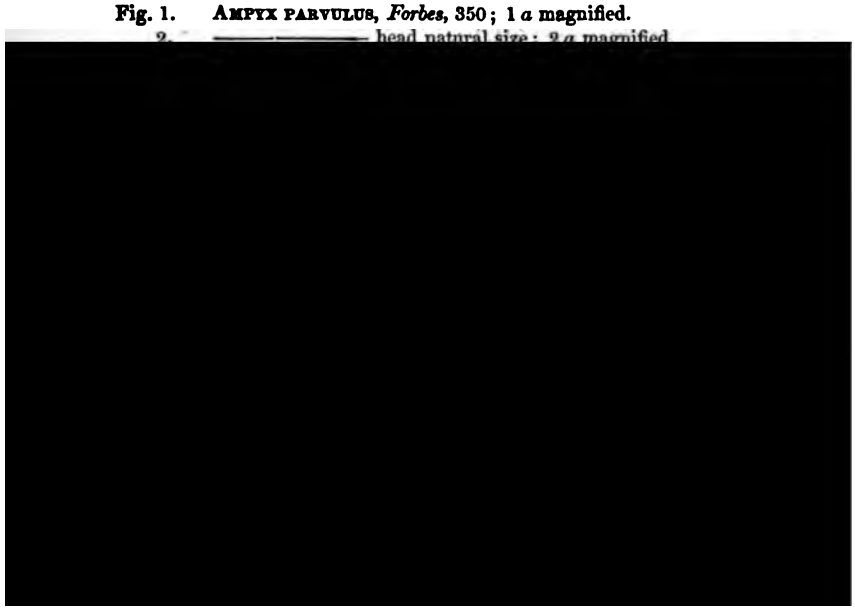


Fig. 3. CALYMENE TUBERCULOSA, head dissected. The central portion, consisting of a swelled central lobe (Glabella, Dalm.), and fixed cheeks, is all called Glabella by Hawle and Corda.
4. ——————————— labrum magnified.
5. ——————————— surface of body magnified.

Plate XIII.

Fig. 1. ORTHOCERAS MARLOENSE, *Phillips*, 353 *a*, direct back ? view; *b*, side view.
2. ORTHOCERAS PERELEGANS, *Salter*, 354, expanded portion (from the collection of Mr. G. Cocking, Ludlow).
3. ——————————— larger specimen, from Usk; 3 *a*, magnified to show the transverse striæ.
4. ——————————— young curved portion, Usk.
5. ORTHOCERAS TEXTILE, *Phillips*, 353, young specimens; 5 *a*, their surface magnified.
6. ——————————— older portion; both figures from Professor Phillips' drawings.

Plate XIV.

Fig. 1. THECA ANCEPS, *Salter*, 355, front, edge view, and section; *a* magnified.
2. LOXONEMA (TEREBRA) SINUOSA, *Sowerby*, 357. The species is probably allied to *M. articulata* and *corallii*, and is therefore, perhaps, a *Murchisonia*. The band appears distinct in the older state, and our figure shows it.
3. MURCHISONIA POLYGLYPHA, *Phillips*, 357, internal cast; 3 *a* magnified portion of exterior.
4. PLEUROTOMARIA QUADRISTRIATA, *Phillips*, 356, 4 *a*, magnified.
5. PLEUROTOMARIA FISSICARINA, *Phillips*, 357, 5 *a*, same specimen magnified, and showing the double keel which encloses the band.
6. ——————————— same species, showing the keels very distinctly.
7. EUOMPHALUS QUALTERIATUS, *Schlotheim*, 356; a somewhat crushed example.
8. EUOMPHALUS ALATUS, *Hisinger*, var. SUBUNDULATUS, 356.
9. ——————————— same variety, under surface of a young whorl, somewhat angular.
10. ——————————— ditto, large specimen from Botville, 10 *a*, magnified.
11. EUOMPHALUS PRÆNUNTIUS, *Phillips*, 357; internal cast, a portion of upper surface of the whorl enlarged to show the spiral flutings of the base of the preceding whorl impressed upon it.
12. BELLEROPHON OBTECTUS, *Phillips*, 356.

Plate XV.

Fig. 1. PLEUROTOMARIA BALTEATA, *Phillips*, 358; 1*, surface and band magnified.
2. ——————————— showing the mouth, May Hill.

Plate XVI.

Fig. 1. PLEURORHYNCHUS ÆQUICOSTATUS, *Phillips*, 359; 1 *a*, magnified, Woolhope.
2. ——————————— a fine specimen from Dudley; 2 *a*, 2 *b*, magnified.

Plate XVII.

Fig. 1. ORTHONOTA CINGULATA, *Hisinger*, 360, Dudley.
2. ——————————— from Usk, somewhat distorted out of the regular transverse shape.
3. ORTHONOTA EXTRASULCATA, *Salter*, 361.

Plate XVIII.

Fig. 1. ORTHONOTA TRIANGULATA, *Salter*, 361.
2. ——— these specimens are of normal shape, and show the elevated beak, more distant from the anterior side than in *O. cingulata*.
3. 4. 5. 6. ——— wide varieties.
7. ——— oval variety, the beak subcentral.

Plate XIX.

Fig. 1. ORTHONOTA RIGIDA, *Sowerby*, 362.
2. ——— flattened by pressure.
3. ORTHONOTA INORNATA, *Phillips*.

Plate XX.

Fig. 1. MYTILUS QUADRATUS, *Salter*, 363; an edge view.
2. MYTILUS PEROVALIS, *Salter*, 363, the impression of the exterior; 2*a*, a cast in wax from this; 2*b*, edge view.
3. MYTILUS GRADATUS, *Salter*, 363.
4. ——— more convex specimen.
5. ——— var. with expanded wing.
6. MYTILUS? UNGUICULATUS, *Salter*, 365, a cast of the interior of the right valve; 6*a*, the same magnified.
7. MYTILUS (INOCERAMUS) MYTILIMERIS, *Conrad*? 364, an internal cast, but with the striæ of growth.
8. ——— edge view of a Dudley specimen.
9. ——— Dudley.
10. MYTILUS (INOCERAMUS) CHEMUNGENSIS, *Conrad*? 365.
11. ——— younger shell, *a*, magnified.
12. MYTILUS EXASPERATUS, *Phillips*, 364; the figure is drawn from portions of two specimens which evidently are of the same species.
13. MYTILUS PLATYPHYLLUS, *Salter*, 364.
14. ——— var. β.

Plate XXI.

Fig. 1. ACTINODONTA CUNEATA, *Phillips*, 366.

Plate XXIII.

Fig. 1. AVICULA AMPLIATA, *Phillips*, 367.
2. AVICULA (PTERINEA?) PLANULATA, *Conrad*, 368, interior of the left valve. Dudley Shales.
3. ——— large specimen from Rock Farm, May Hill. Wenlock limestone.
4. ——— young, and rounder than usual. Usk.
5. AVICULA TRITON, *Salter*, 368, an internal cast.

Plate XXIV.

Fig. 1. LINGULA CRUMENA, *Phillips*, 369.
2. ——— younger.
3. ——— ditto.
4. ——— ditto, distorted from the triangular shape.
5. ——— ditto, wide variety.

Plate XXV.

Fig. 1. LINGULA GRANULATA, *Phillips*, 370; *a*, magnified.

Plate XXVI.

Fig. 1. LINGULA PARALLELA, *Phillips*, 370; 1*a*, edge view; 1*b*, portion magnified.
2. ORBICULA FORBESII, *Davidson*, 371, lower valve; 2*a*, edge view; 2*b*, byssal sinus magnified.
3. LEPTÆNA LEPISMA, *Dalman*, var. MINOR, 371; 3*a*, interior cast of ventral valve.
4. ——— Aymestry specimen; 4*a*, interior of ventral valve; 4*b*, outside of valve, 4*c*, interior of ditto.

Plate XXVII.

Fig. 1. STROPHOMENA APPLANATA, *Salter*, 380, internal cast of dorsal valve; 1*a*, same magnified, and showing the extended points of the ribs.
2. ——— exterior of ventral valve, 2*a*, magnified.
3. ORTHIS INFLATA, *Salter*, var. β RETRORSA, 373, dorsal valve, the exterior surface partly worn off; 3*a*, edge view of ditto; 3*b*, with the ventral valve added, to show the entire convexity.
4. ——— ventral valve, external surface, the ribs twice forked—our figure does not show this so distinctly as the specimen; 4*a*, interior cast of the same valve.
5. ORTHIS TESTUDINARIA, *Dalman*, 373, exterior of ventral valve.
6. ——— interior of same valve.
7. ——— internal cast of ditto.
8. ——— flat dorsal valve; 8*a*, portion of the hinge line magnified, to show the upturned ends of the ribs; 8*b*, more magnified, the transverse close striæ between the ribs only.
9. ——— dorsal valve more convex, exterior.
9*a*. ——— interior cast of same valve.
10. ——— dorsal valve; a very convex variety approaching *O. polygramma*, exterior.

Plate XXVIII.

Fig. 1. HYPOTHYRIS SEMISULCATA, *Dalman*, 382, exterior of a full grown specimen; 1*a*, front view of same.
2. ——— interior cast of dorsal valve, the centre channelled at first, then elevated.

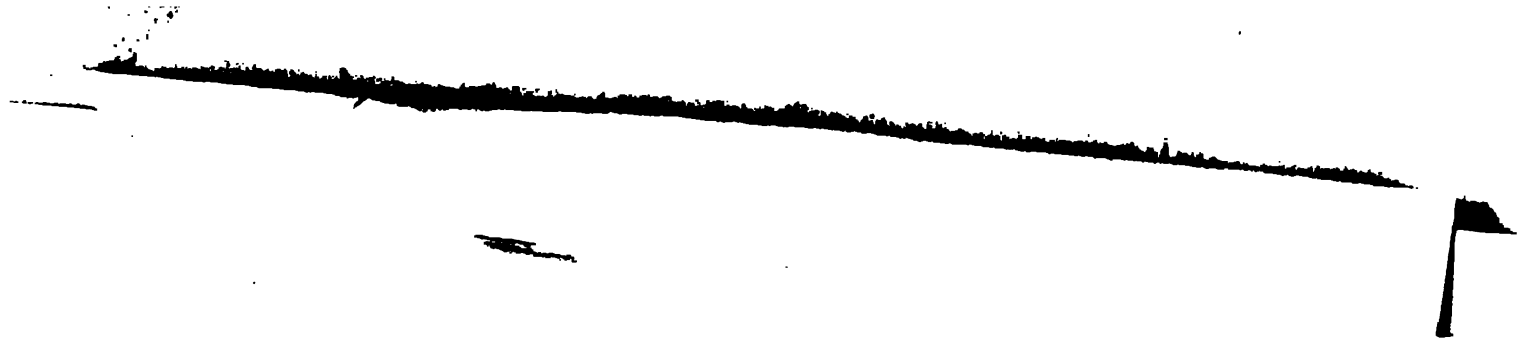
Fig. 3. HYPOTHYRIS SEMISULCATA, another interior cast.
4. ——————— ventral valve, interior.
5. ——————— another specimen.
6. ——————— dorsal valve, cast magnified.
7. ——————— ventral valve, ditto.
8. ——————— more convex variety (*Terebrat. nucula*, Sil Syst?); 8*a*, front view.
9. HYPOTHYRIS BOREALIS, *Schlotheim*, var. DIODONTA; 9*a*, ventral view.
10. ——————— full-grown shell; 10*a*, front view.
11. ——————— var. with many ribs on the dorsal fold.
12. ——————— same var., ventral shell.
13. ——————— specimen with three central ribs.
14. ——————— side view.

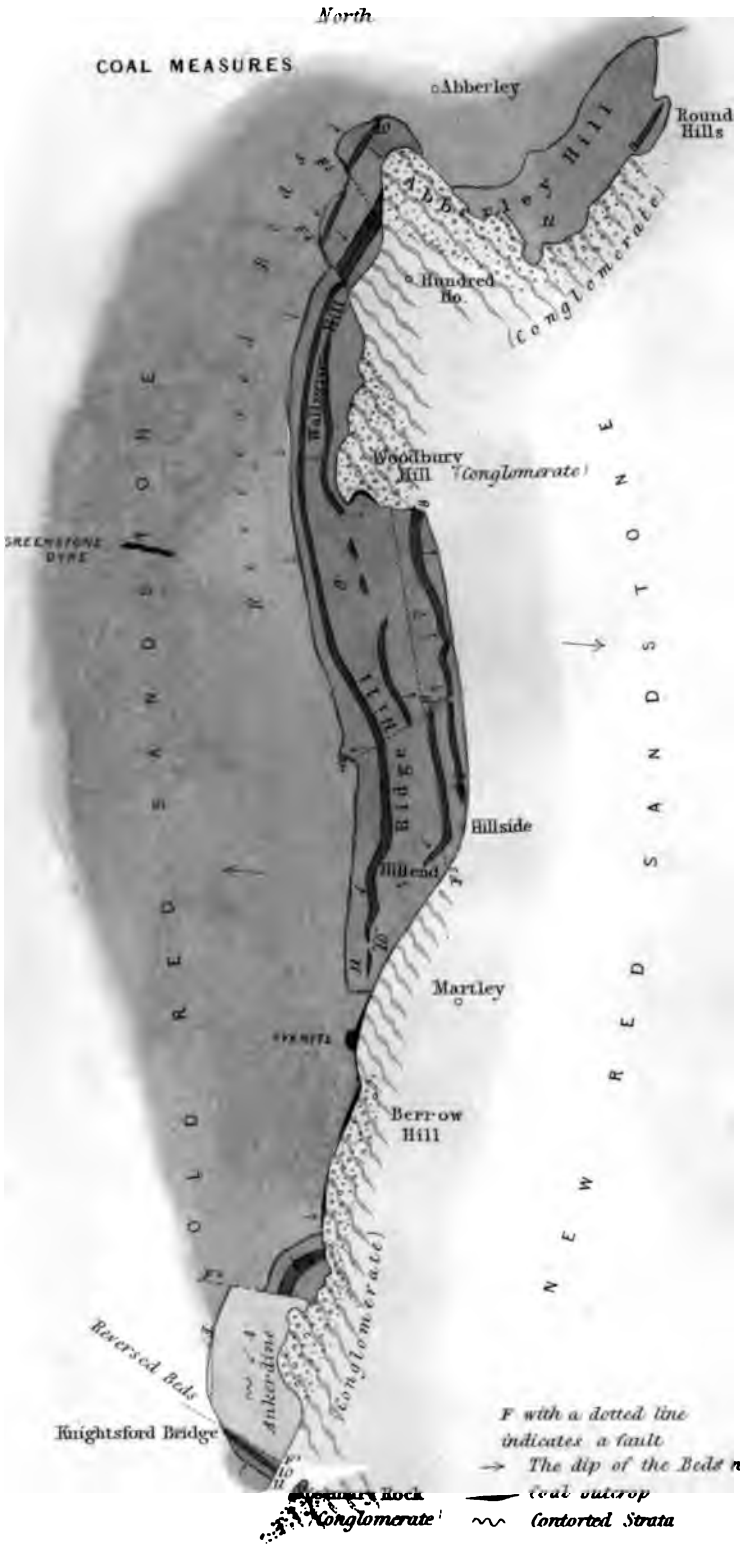
Plate XXIX.

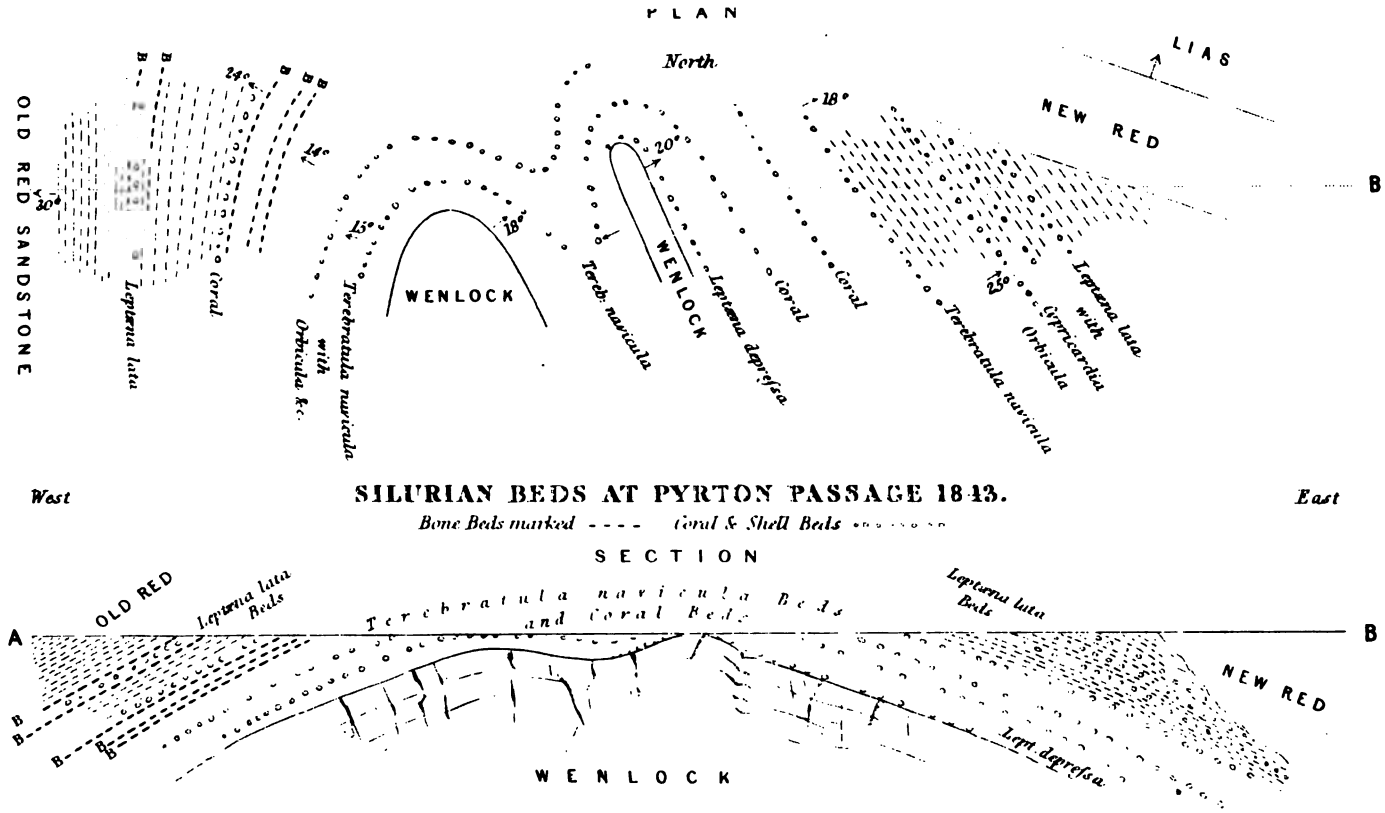
Fig. 1. PALECHINUS PHILLIPSIÆ, *Forbes*, 384; 1*a*, portion magnified, showing the poriferous and interambulacral plates.

Plate XXX.

Fig. 1. SERPULITES CURTUS, *Salter*, 333, young portion.
2. ——————— older portion, showing the lines of (growth?): they are very obscure. The two specimens are put together to show what curve the entire shell appears to have taken.
3. FAVOSITES? FAVULOSA, *Phillips*, 385, natural size; 3*a*, slightly enlarged, to show the clusters of larger tubes among the small ones; 3*b*, more highly magnified.
4. ACTINOPHYLLUM PLICATUM, *Phillips*, 386, impression of lower surface; 4*a*, corresponding impression of the upper surface.
5. ONCHUS DECORUS, *Phillips*, 226; 5*a*, magnified.




North
COAL MEASURES
Abberley
Round Hills
Abberley Hill
Conglomerate
Hundred Ho.
Woodbury Hill
Conglomerate
GREENSTONE DYKE
Hillside
Hillend
Martley
Berrow Hill
Conglomerate
Reversed Beds
Knightsford Bridge
Conglomerate
OLD RED SANDSTONE
NEW RED SANDSTONE
F with a dotted line indicates a fault
The dip of the Beds near the surface
Coal outcrop
Contorted Strata


PLAN
North
LIAS
NEW RED
A
B
OLD RED SANDSTONE
Lepæna lata
coral
Terebratula navicula with Orbicula &c.
WENLOCK
Lepæna depressa
Lepæna lata with Cypricardia Orbicula
Terebratula navicula
West
East
SILURIAN BEDS AT PYRTON PASSAGE 1843.
Bone Beds marked ---- Coral & Shell Beds
SECTION
OLD RED
Lepæna lata Beds
Terebratula navicula Beds and Coral Beds
Lepæna lata Beds
NEW RED
Lepæ. depressa
WENLOCK

Pl. 3.

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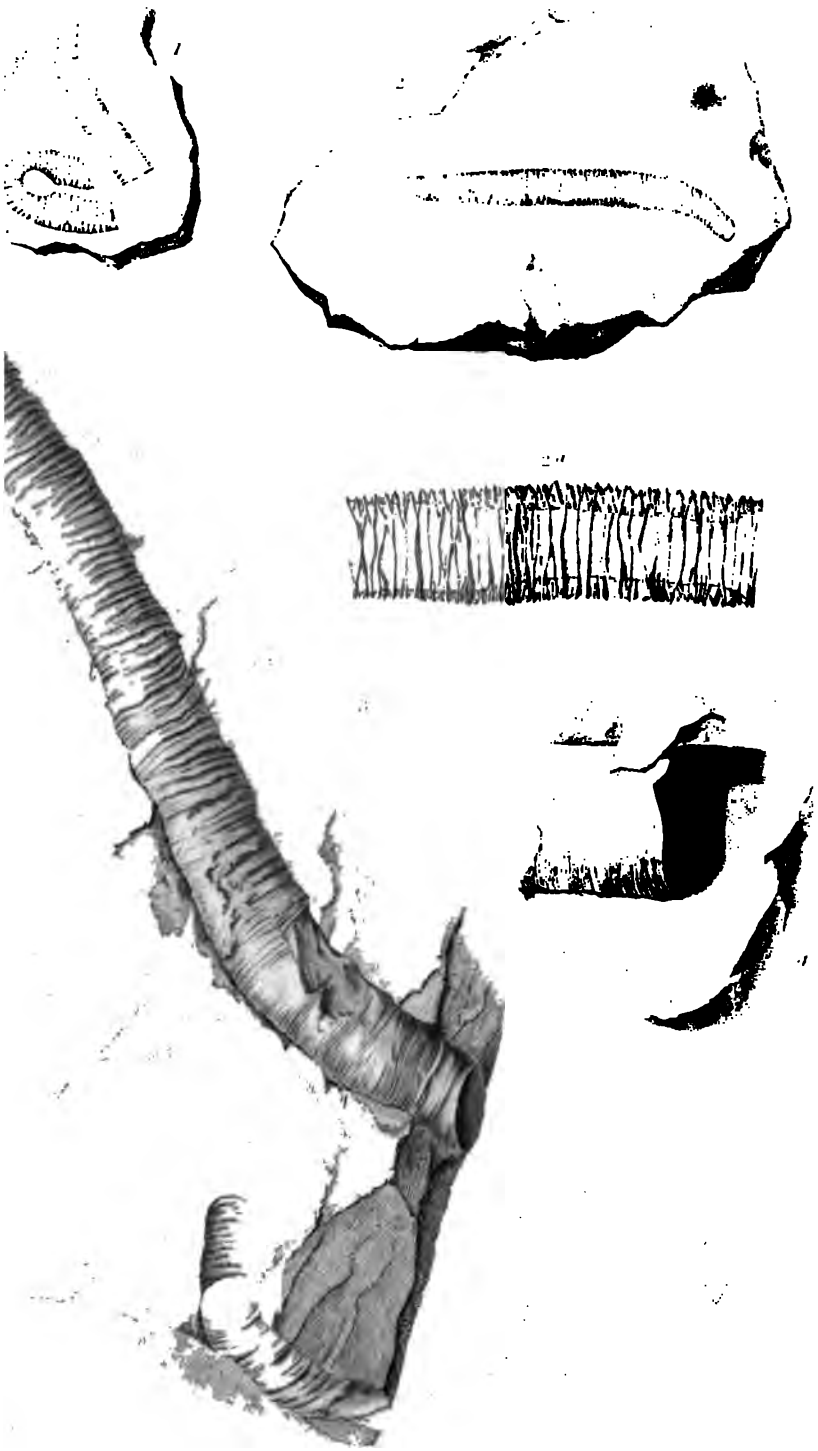
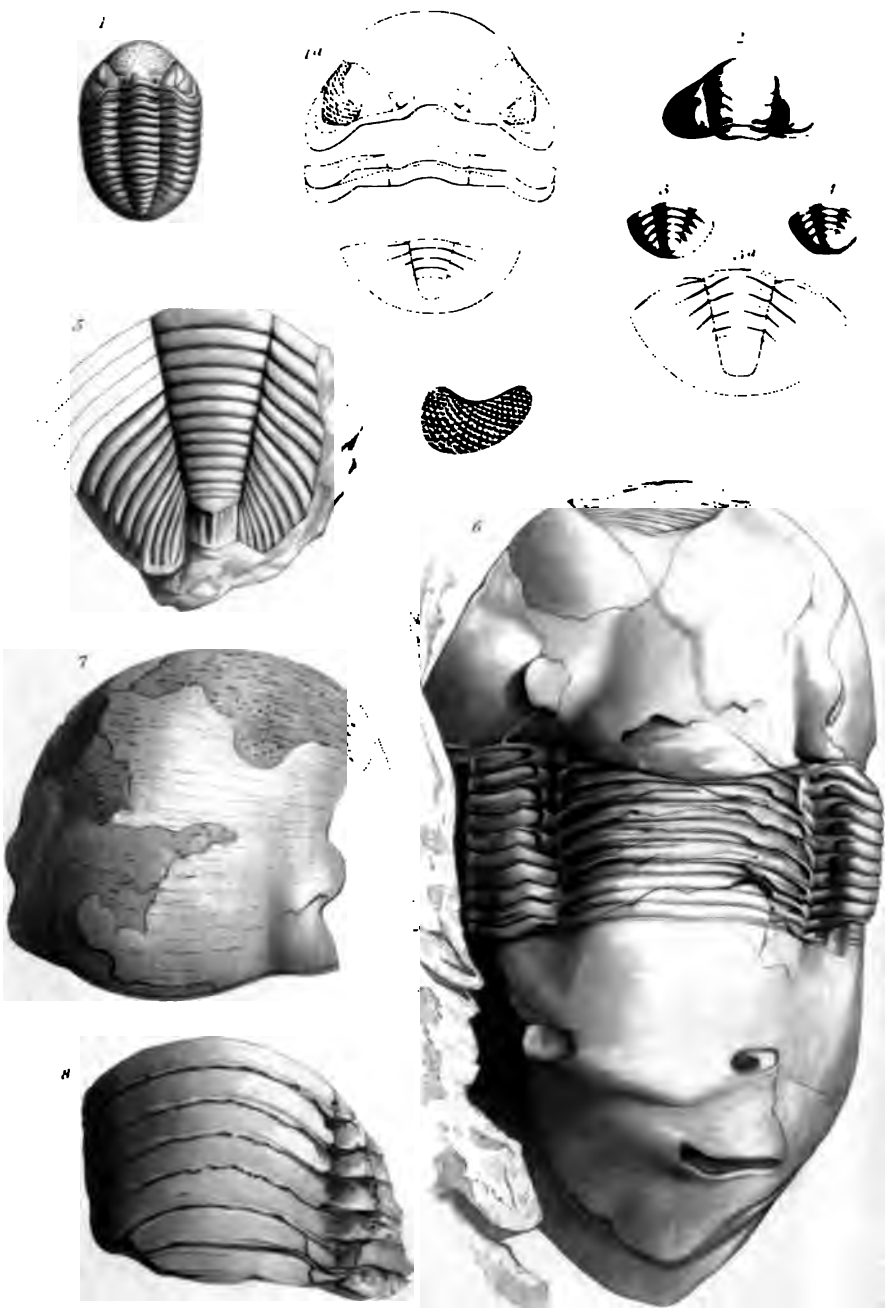


1 2 TRACHYDERMA GRIMACEA *Phillips*
3 4 SQUAMOSA ,, *D°*



1. *Phacops Stokesii*. *5* *Phacops Dalmannia affinis.*
2–4. *Downingiæ*. *6–8.* *Illænus Rosenbergii*

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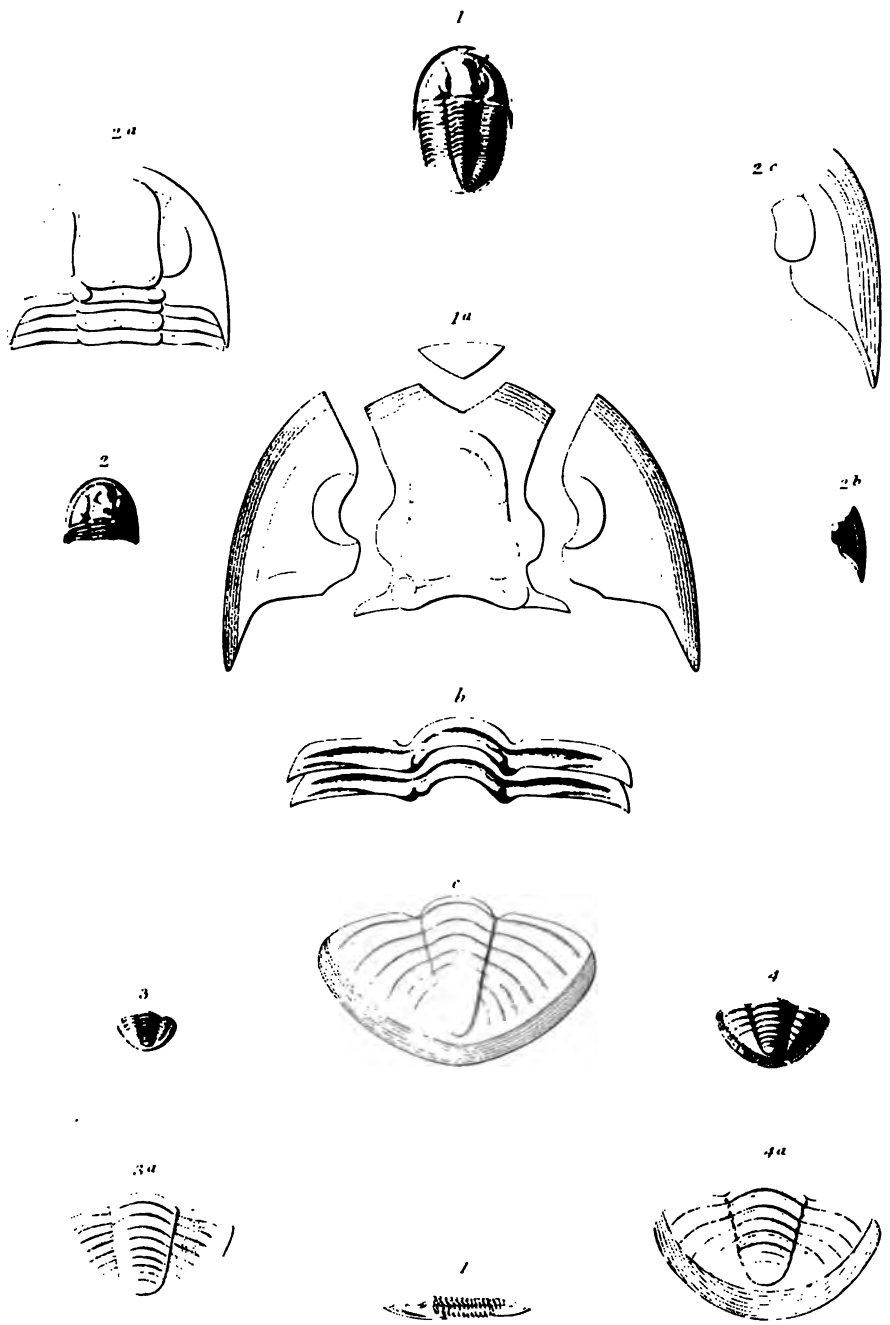
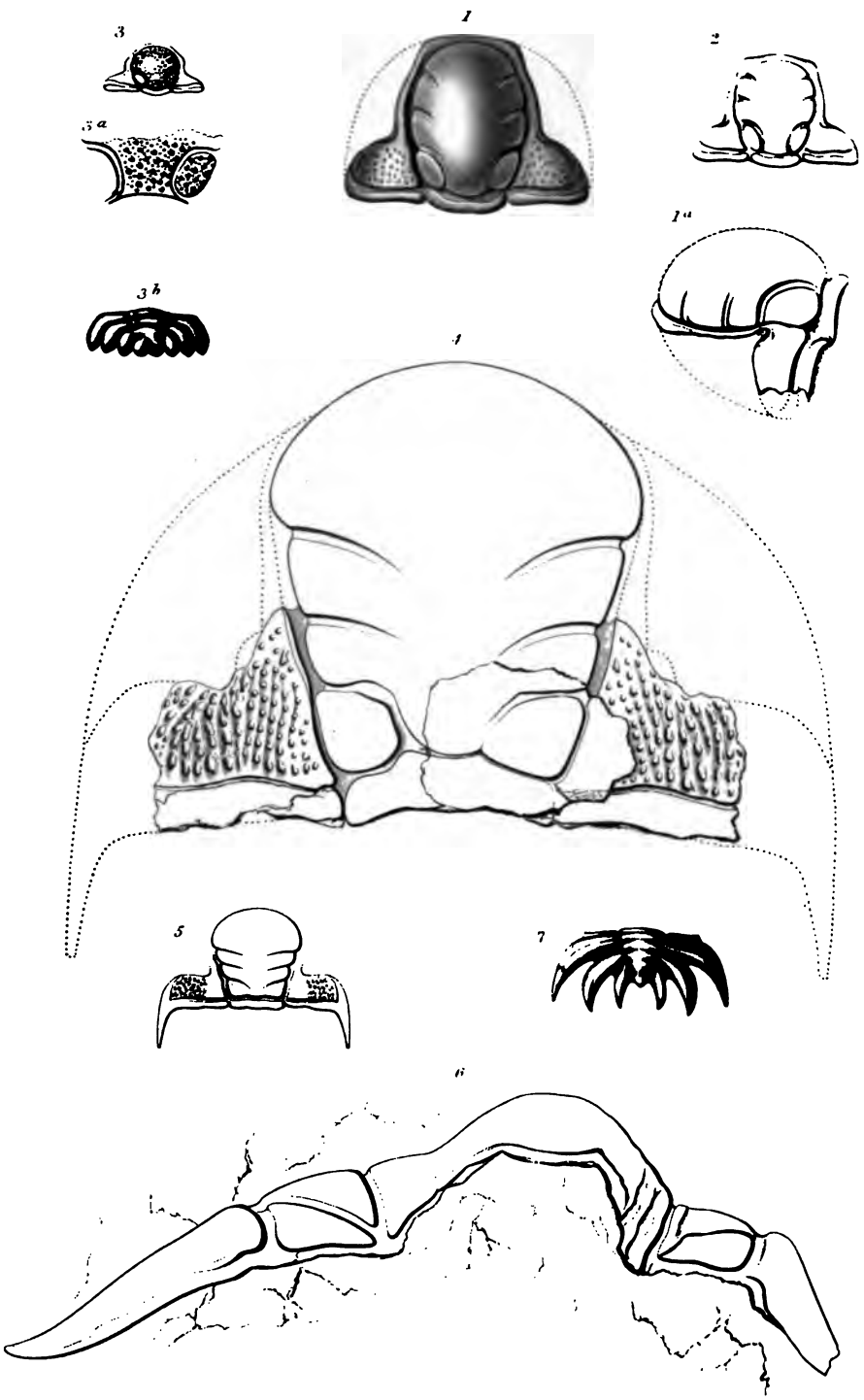
PROETUS
Silurian



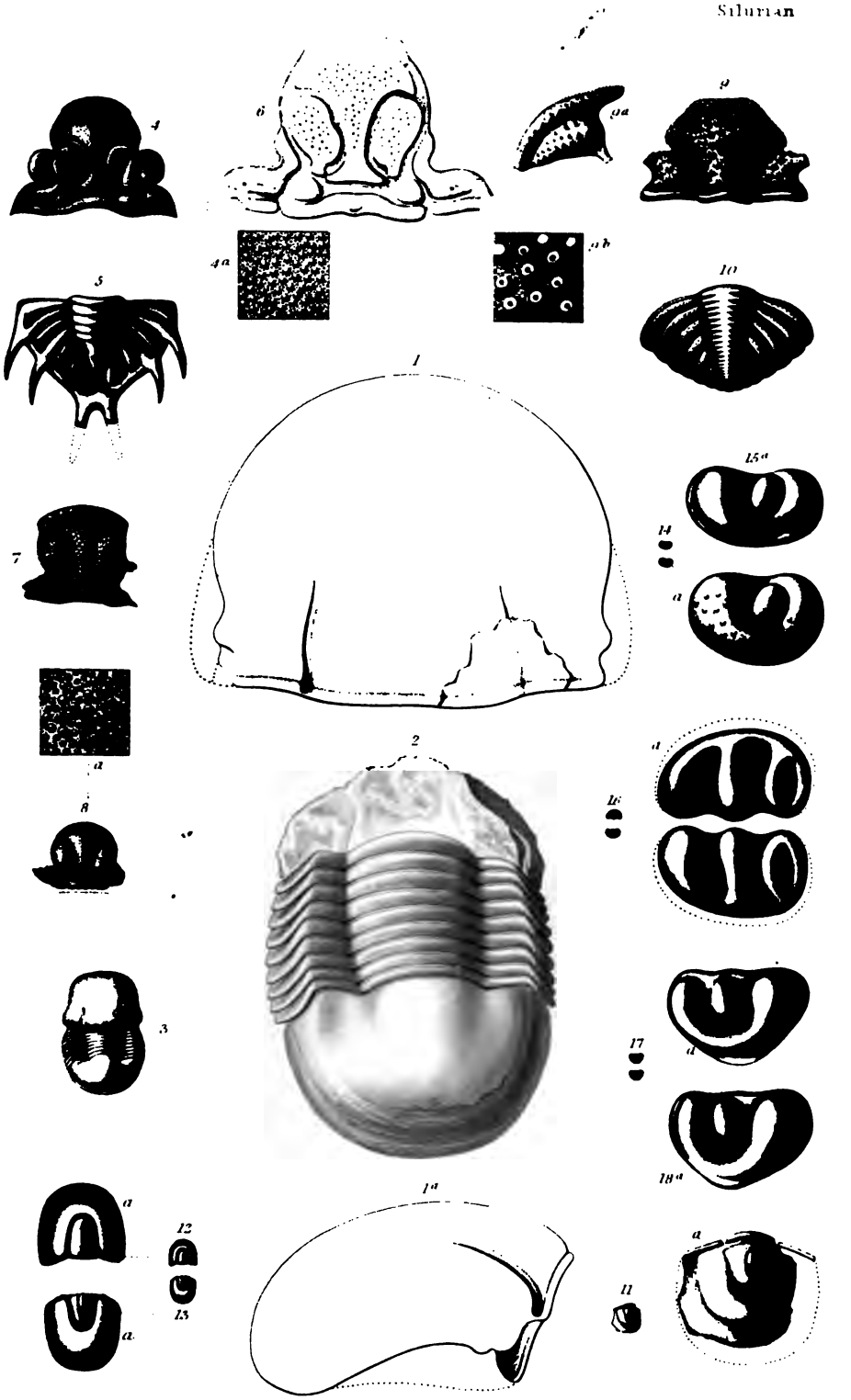
1 PROETUS LATIFRONS *M'Coy* 3 PROETUS *sp.*
2 - - *sp.* 4 - *sp.*



1 3. Sphærexochus juvenis.
4 7. Cheirurus speciosus.

ological Survey of the United Kingdom.

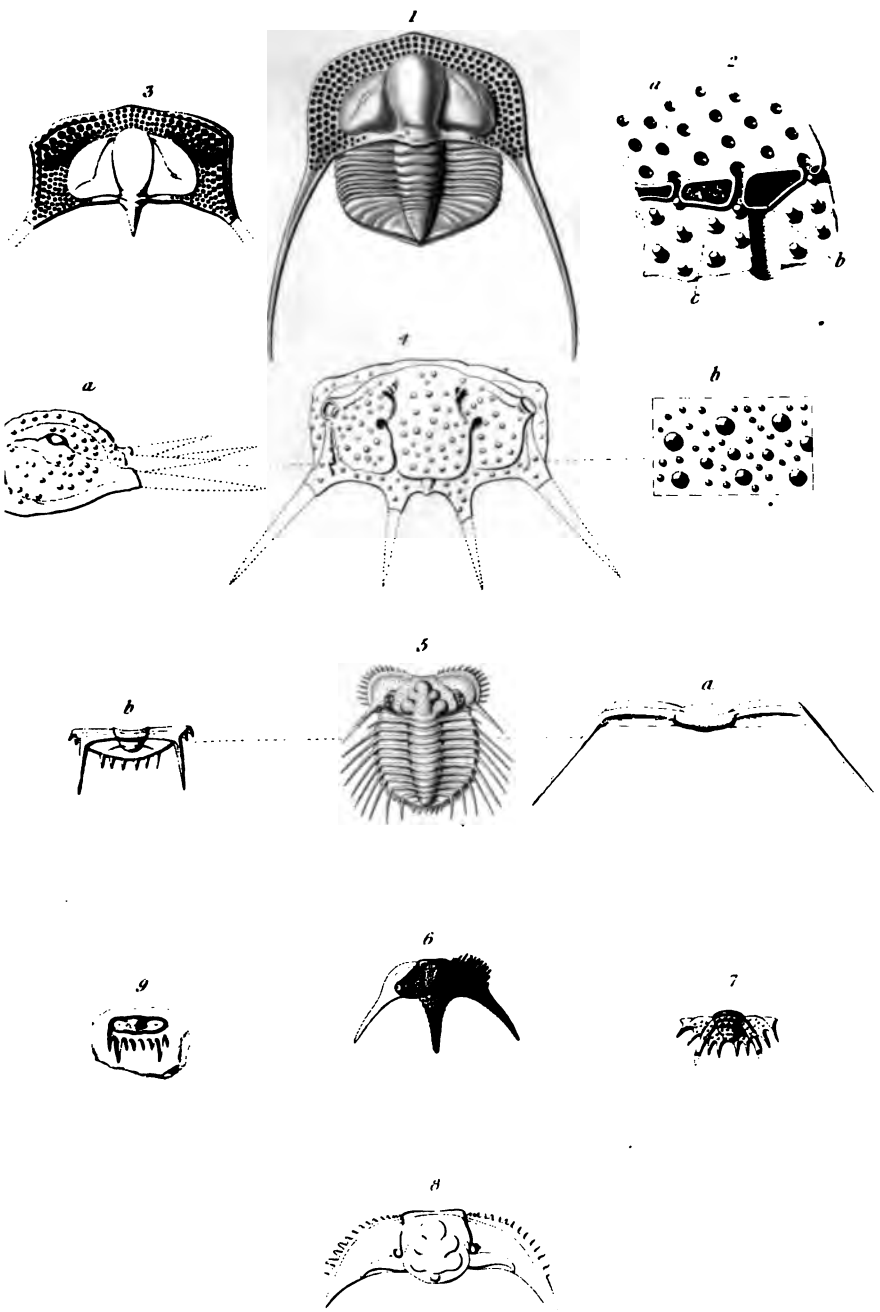
CRUSTACEA
Silurian



1–3. *Illænus Bowmanni*.
4–6. *Lichas laxatus*
7 — —— *verrucosus*.
8 — —— *sp. undescribed*.
9 *Cybele saccostata*.
11 — *Agnostus trinodus*.
12 13 — — — *S. conicurus*.
14 15. *Beyrichia tuberculata*.
16 — —— — *complicata*.
17 18 — —— *gibba*.

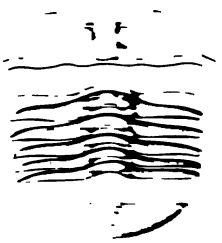
gical Survey of the United Kingdom.

TRINUCLEUS } Silurian.
ACIDASPIS }



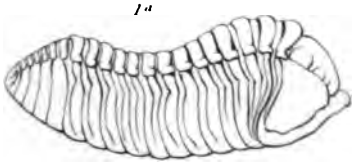
1 2 Trinucleus ornatus. *4 5 Acidaspis bispinosus*

3 " " var. Favus. *6 9 " Brightii.*

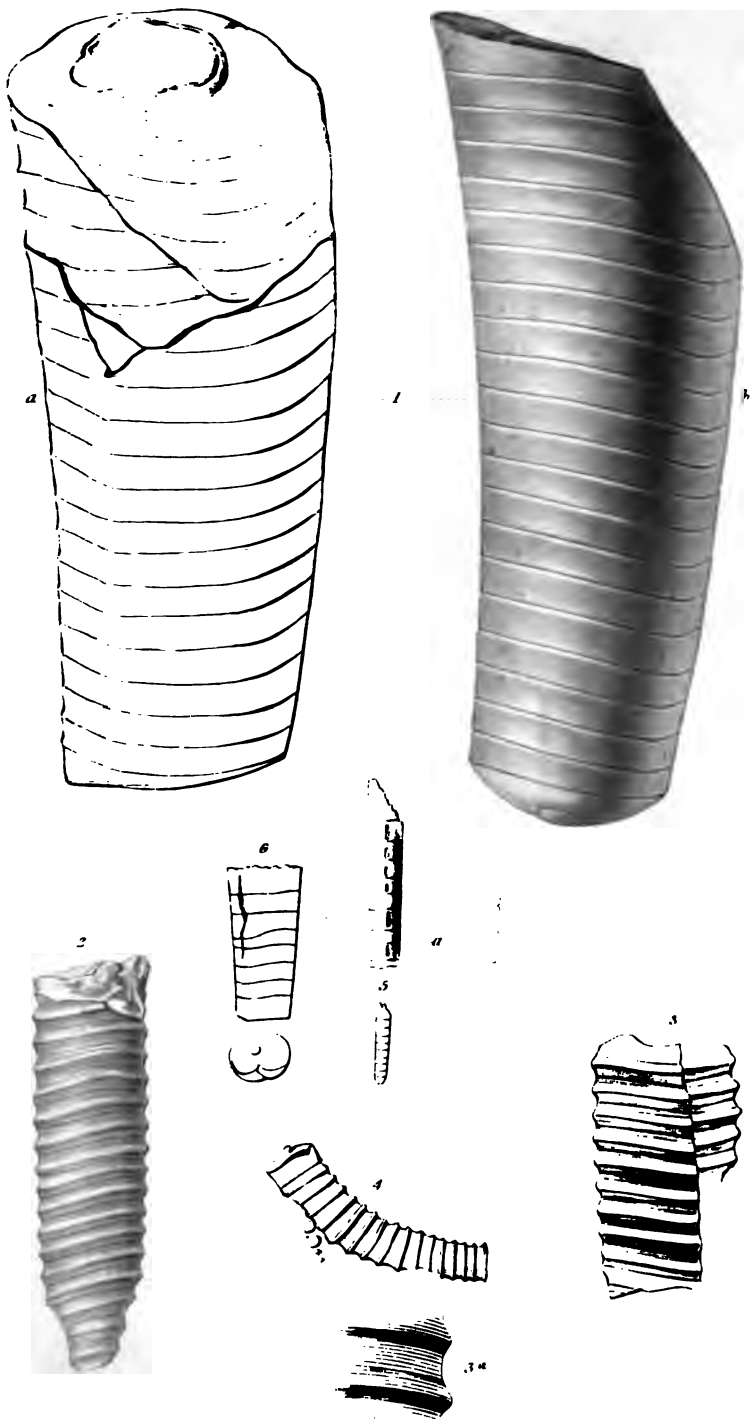


AMPYX [illegible] *Forbes*

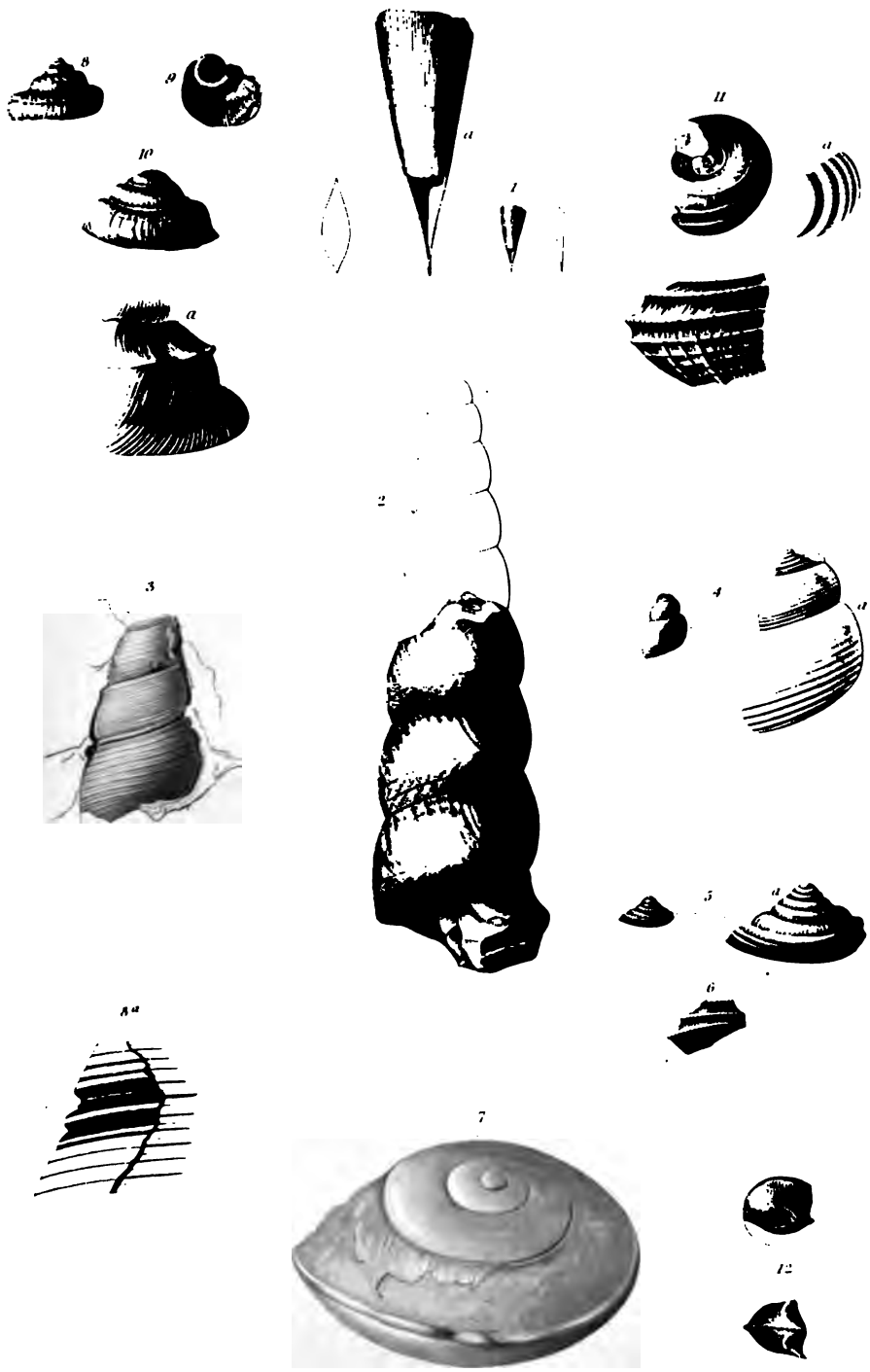
CALYMENE BREVICAPITATA *Portlock*.



CALYMENE [illegible] *Salter*



1. ORTHOCERAS MARLOENSE *Phillips*
2. 4 _ _ _ _ PERELEGANS *Salter.*
5. 6. _ _ . _ TEXTILE *Phillips.*

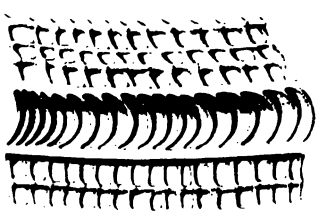


1. *Theca anceps.*
2. *Terebra? sinuosa.*
3. *Murchisonia polyglypha.*
4. *Pleurotomaria quadristriata.*
5. 6. *Pleurotomaria fissicarina.*
7. *Euomphalus qualteriatus.*
8–10. *——— alatus var. subundulatus.*
11. *——— ——— ——— præruntius.*
12. *Bellerophon obtectus.*

Geological Survey of the United Kingdom.

PLEUROTOMARIA
(Silurian

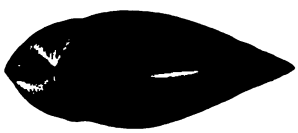
1.



PLEUROTOMARIA BALTEATA *Phillips*

PLEURORHYNCHUS ÆQUICOSTATUS ___ *Phillips*

1



2

3

1, 2. ORTHONOTA CINGULATA *Hisinger*
3. EXTRASULCATA *Salter*

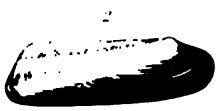
ORTHONOTA
(Silurian)

ORTHONOTA [illegible] *Salter*

W H Bodily del.

1

2



3

1 2 ORTHONOTA RIGIDA *Sowerby*

3 " " " INORNATA " *Phillips*

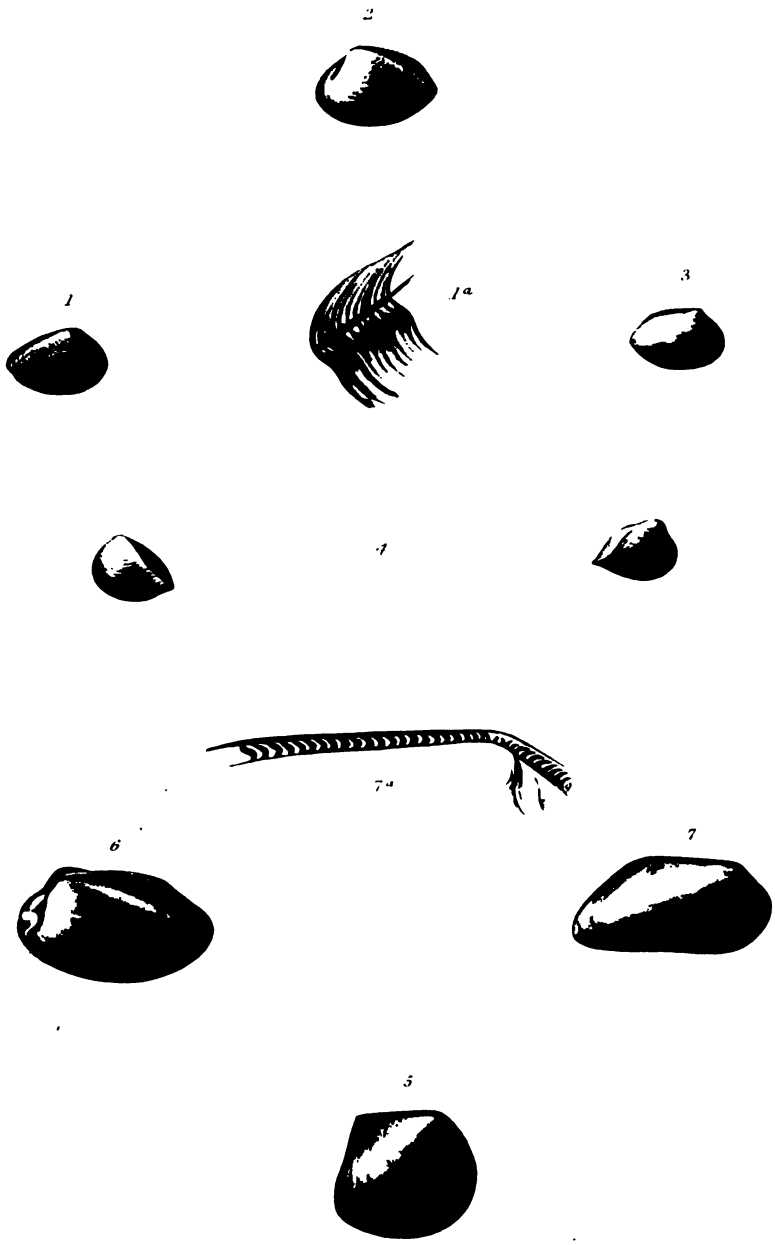
1 MYTILUS QUADRATUS *Sailer*
2 " " PERONALIS *Sailer*
3,5 " " GRADATUS " *Sailer*
6 " " UNGUICULATUS *Sailer*
7, 9 MYTILUS MYTILIMERIS *Conrad*
8, 11 " CREMUNGENSIS *Conrad*
12 " EXASPERANTUS " *Phillips*
13,14 " PLANIMINUS " *Sailer*

ACTINODONTA
ARCA

Sibman

1 4 ACTINODONTA CUNEATA *Phillips*

5 ARCA PRIMITIVA .. *Phillips*



1 _ _ 4 NUCULA COARCTATA *Phillips* • 6. NUCULA LINGUALIS _ *Phillips*

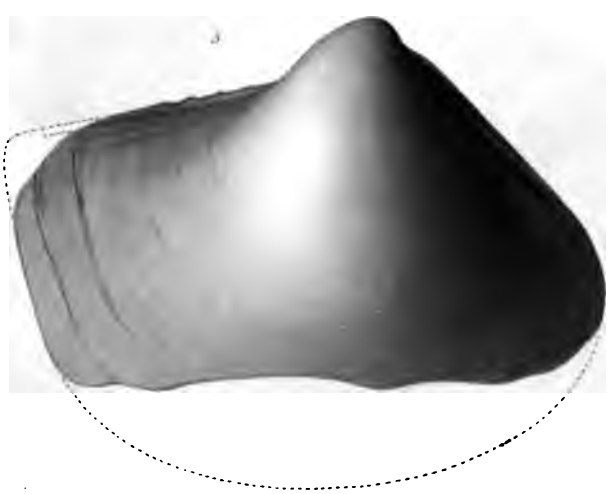
5. _ _ _ _ _ _ _ DELTOIDEA _ *d°* _ _ 7. _ _ _ _ RHOMBOIDEA _

1

4

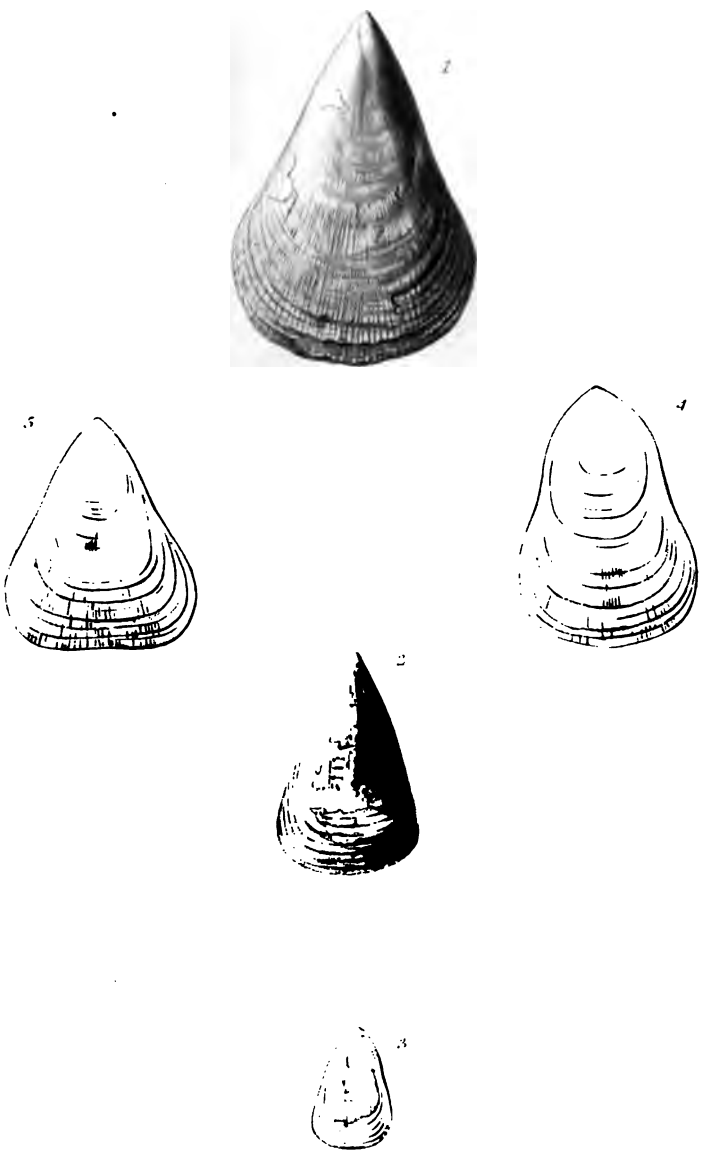
3

2

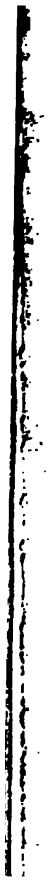


1 AVICULA AMPLIATA *Phillips*
2 4 " PLANULATA " *Conrad*
5 " TRITON *Salter*

W.E.Baily del



LINGULA CRUMENA *Phillips.*



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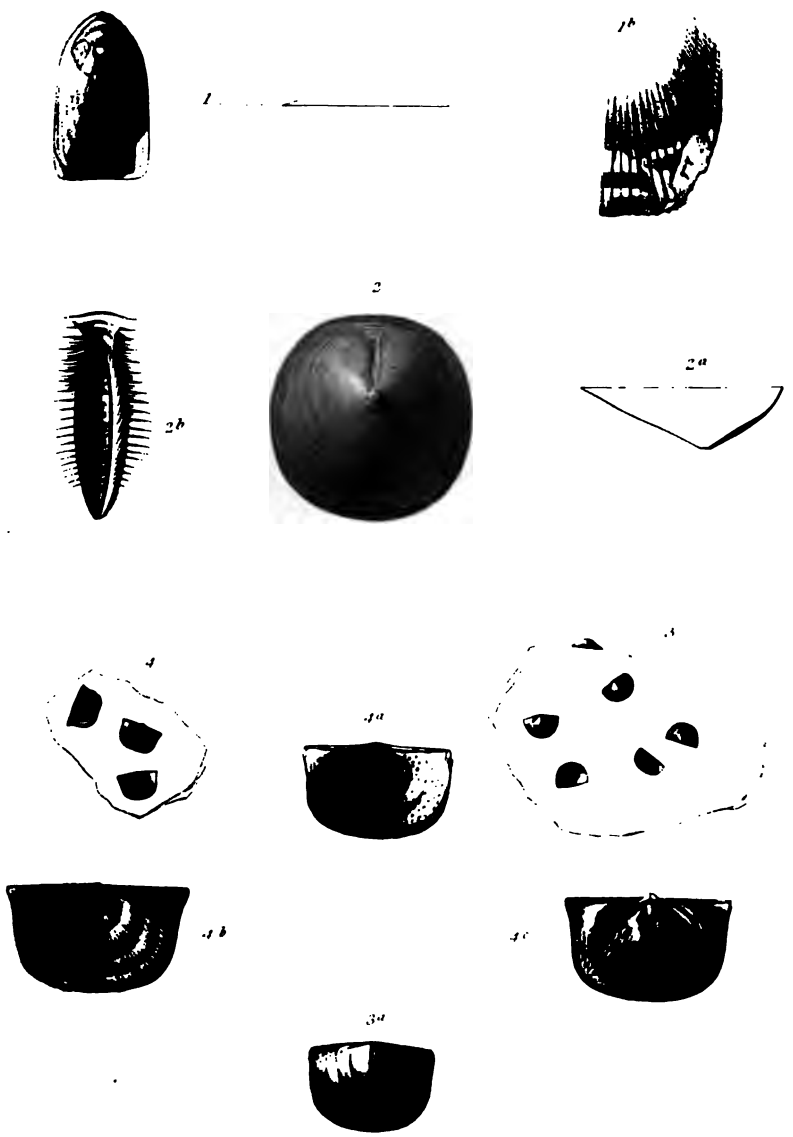
1

LINGULA GRANULATA *Phillips*.

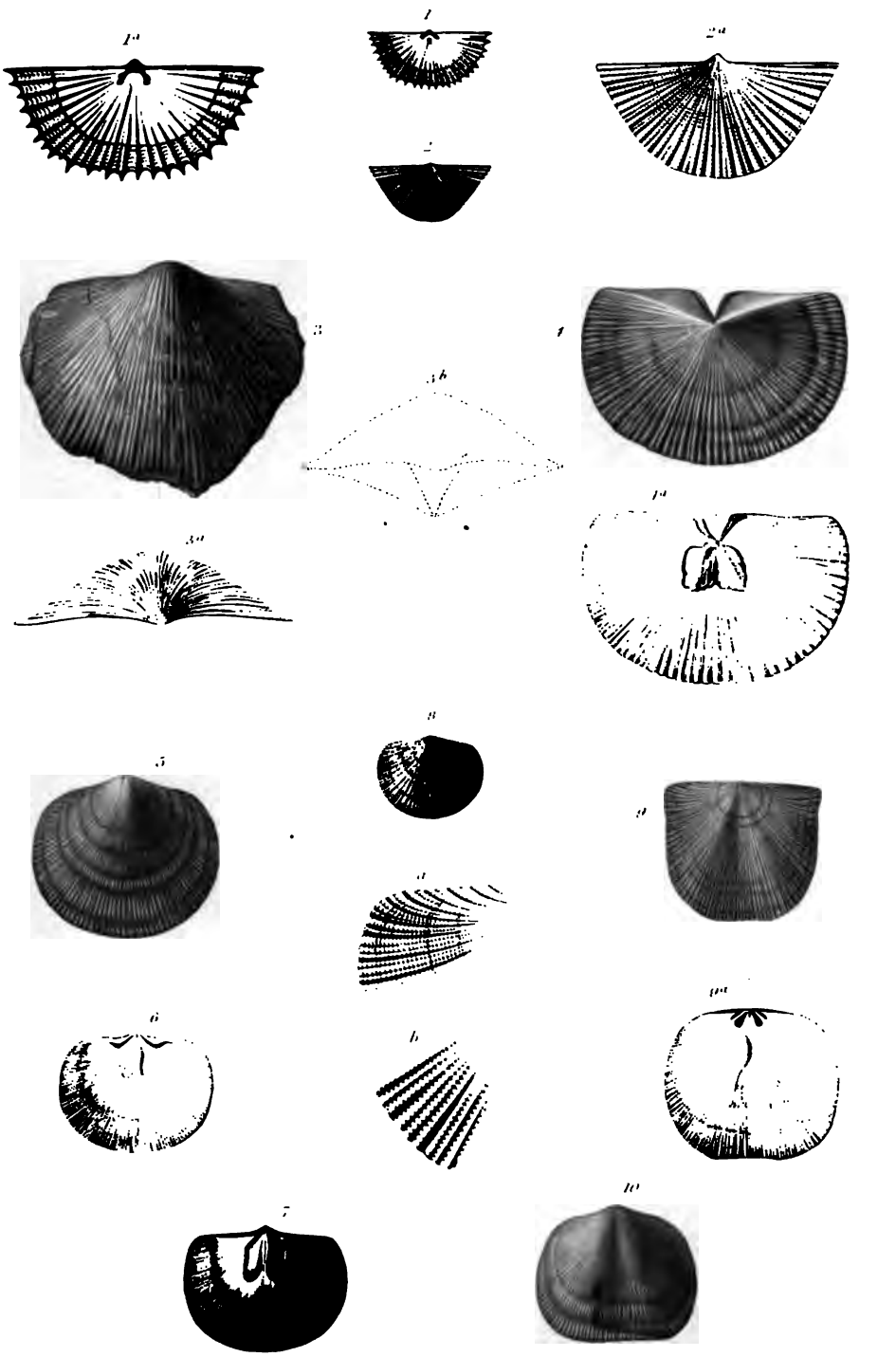
Lips del!



1. Lingula parallela.
2. Orbicula Forbesii.
3. 4. Leptæna lepisma. var-minor.

H Bauly del.

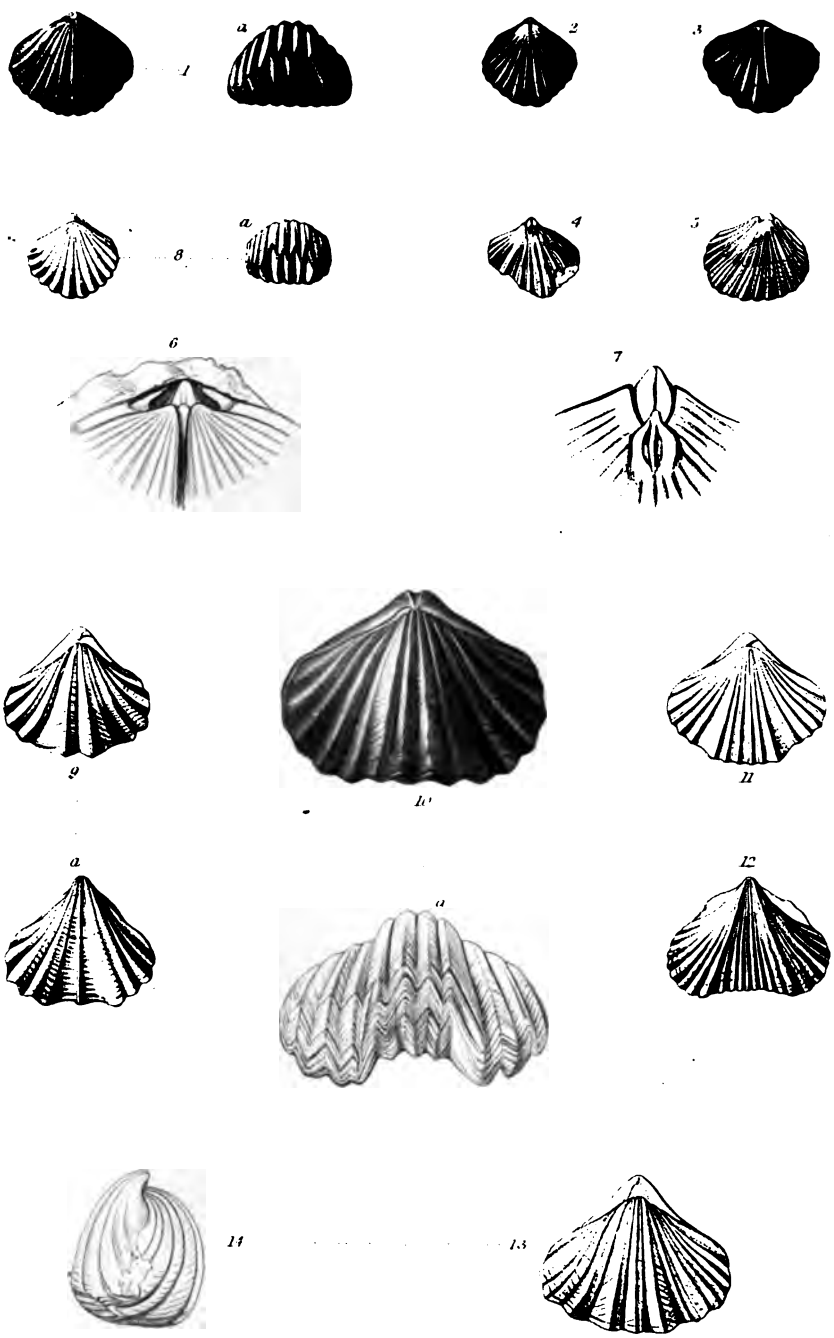
Geological Survey of the United Kingdom. STROPHOMENA Albertus
ORTHIS



1, 2 STROPHOMENA APPLANATA *Salter.*
3, 4 ORTHIS INFLATA *Salter.*
5, 10 " TESTUDINARIA *Dalman.*

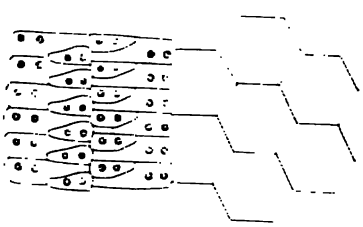
Geological Survey of the United Kingdom.

HYPOTHYRIS
Silurian.



1 8 HYPOTHYRIS SEMISULCATA — *Salter (Dalm.)*

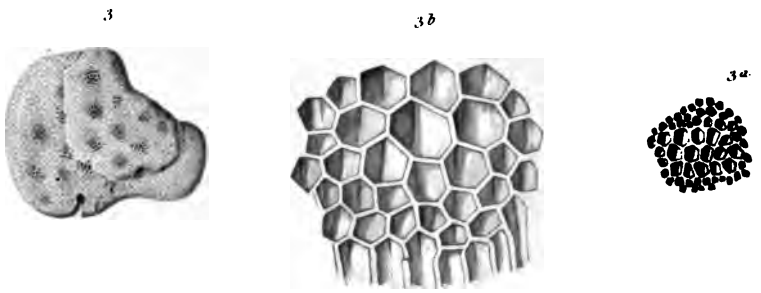
9 14 — — —— BOREALIS — *Schlotheim*

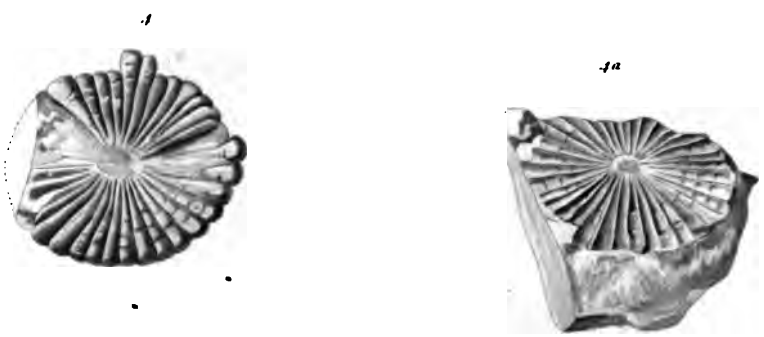


PALECHINUS PHILLIPSII *Forbes*

C.H.Bone del

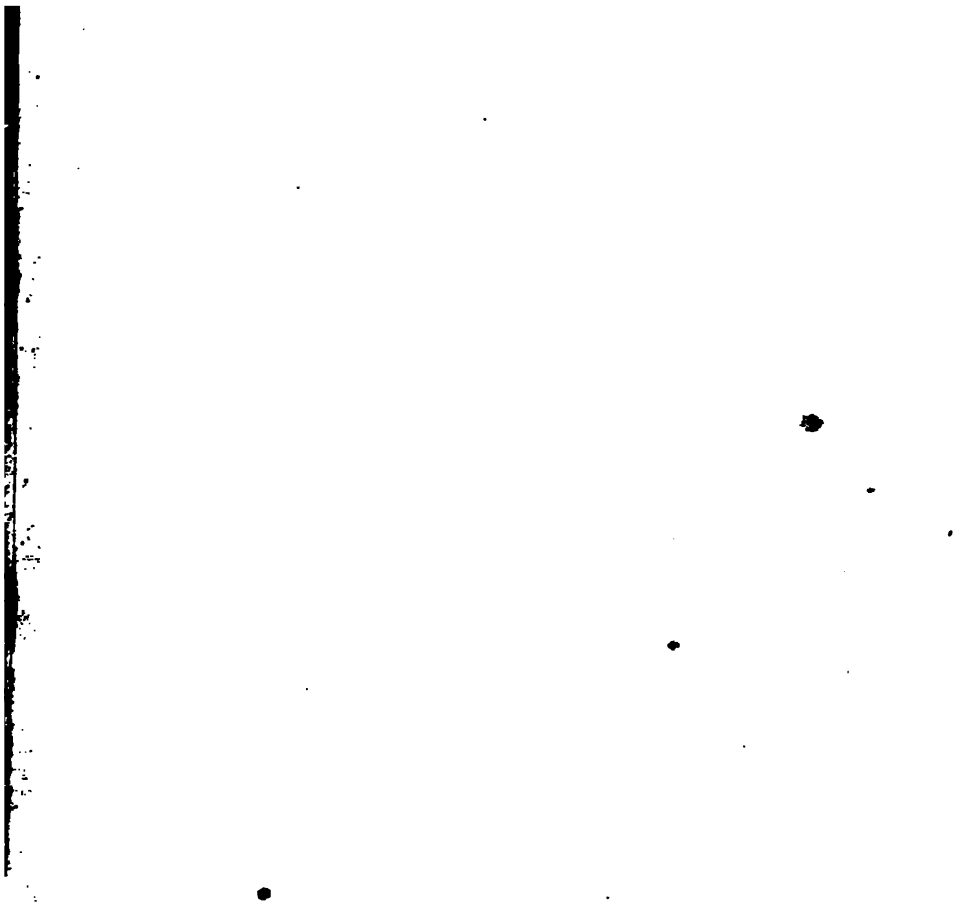
Geological Survey of the United Kingdom. Silurian.)





1 2_Serpulites curtus_Salter. *4 Actinophyllum plicatum_Phillips.*

3 _Favosites? tuvulosa. Phillips. *5_Onchus decorus_ Phillips.*



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